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1884.

EXCERPT MINUTES OF COUNCIL MEETING

Held at 116 *Victoria Street, 8th April*, 1884.

The Rev. Prof. Bonney, D.Sc., F.R.S., President, in the Chair.

Prof. J. W. Judd, F.R.S., was elected a Member of the Society.

EXCERPT MINUTES OF COUNCIL MEETING

Held at 116 *Victoria Street, July 3rd*, 1884.

The Rev. Prof. Bonney, D.Sc., F.R.S., President, in the Chair.
The following gentlemen were elected Members of the Society—

Gustav Seligmann.
Herbert S. Sutton.

GENERAL MEETING

Held in the Library of the Museum of Science and Art, Edinburgh, June 24th, 1884.

Prof Jas. Geikie, F.R.S., in the Chair.

The following papers were read :—

"Forms of Silica." By John Ruskin, D.C.L., Slade Professor at Oxford (communicated by the Local Secretary for Scotland).

"On Welsh Gold," from the Mawddach Valley, Merionethshire. By Mr. T. A. Readwin, F.G.S.

"Application of the Periodic Law to Mineralogy." By Thomas Carnelley, D.Sc., F.C.S., Professor of Chemistry Univ. Coll. Dundee (communicated as above).

"The Origin of the Andalusite Schists of Aberdeenshire." By John Horne, F.R.S.E., H.M.'s Geol. Survey.

"On the Occurrence of Prehnite and other Zeolites in the Rocks of Samson's Ribs and Salisbury Crags." By Andrew Taylor, F.C.S., F.G.S.E. (communicated as above).

"On a New Locality for Zoisite, Loch Garve, Ross-shire." By W. Hamilton Bell, F.G.S.E. (communicated as above).

"On Diatomaceous Deposits in Scotland." By Prof. W. I. Macadam, F.C.S., Hon. Sec. G.S.E.

"Notes on the Albertite Beds of Strathpeffer, Ross-shire." By William Morrison, M.A., Academy, Dingwall (communicated as above).

Mr. Thomson referred to the fact that an allied jet mineral was found imbedded in the oil-yielding bituminous shales of Midlothian. The substance only occurred in small quantities, the largest pieces not exceeding a pound in weight; it is capable of taking a fine polish, very similar to jet—in fact a jet-worker pronounced it at first to be Spanish jet.

"Kyanite Localities in the North, and Staurolite from Presholme, Enzie, Banffshire." By Thomas Wallace, High School, Inverness.

"The Crystallography of Bournonite." By H. A. Miers, B.A., British Museum, Nat. Hist. Dept.

"Notes on the Metallic Veins of the Upper Hartz, Germany." By H. M. Cadell, B.Sc., H.M.'s Geol. Survey (communicated as above).

"Scottish Localities for Actinolite." By Rev. W. W. Peyton.

"On some new forms of Tourmaline from Lockport, New York County." By R. H. Solly.

(These Papers will appear in No. 28.)

THE MINERALOGICAL MAGAZINE

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MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND.

No. 27. JULY 1884. Vol. VI.

On the Existence of Nickel-iron with Widmannstätten's Figures in the Basalt of North Greenland.

By K. J. V. Steenstrup, C.M.S.

(Translated from Meddelelser fra Grönland. Heft 4. 1883.)

AMONG the minerals found in meteorites, there is none which has attracted the general notice to such a degree as the metallic ickel-iron, especially from the fact that it has hitherto never been een for certain in any telluric rocks. Nay, so much stress was laid pon this latter circumstance, that such iron was thought never to occur ere on earth without having been carried to us from the outer uni- erse, and ever since Chladni's report on the iron-mass of Pallas, every ose block of iron lying on the surface of the ground, nay, even deeply nbedded in it, has generally been declared to be a meteorite, if it only ontained a certain percentage of nickel and, which was not always the ase, manifested some crystalline texture, called after the discoverer Widmannstätten's figures." An instance of the value accorded to this ercentage of nickel in iron as affording a proof of meteoric origin we

have in the iron brought by Sir John Ross from Sowallick (Savilik). For that famous investigator of the polar regions received from the Esquimaux in Melville Bay some knives consisting of a piece of bone, somewhat like a paper knife, in the edge of which a range of small round iron discs were laid into a furrow. The natives said that they found the material of these on a mountain where two large stones were lying, of which one could not be worked with their tools, whereas they could cut the other to pieces, and that from this latter they took out the small round iron balls and beat them flat. This iron contained nickel, and from that time it has been generally stated that the Esquimaux in Melville Bay made use of meteoric iron.

Professor Nordenskiöld, therefore, after searching in vain for such iron at Fortune Bay, on Disco Island, in North Greenland, where the Rudolph iron is thought to have been found, and being led by the natives to Blaafjeld, Uifak,* did not hesitate to declare the iron masses lying there to be meteorites, when convinced that they contained nickel, and showed Widmannstätten's figures, although he found that iron of the same kind was firmly incorporated in the rock on which the blocks were lying.† He very earnestly denied that this discovery might be interpreted as if the iron were of a telluric origin ‡ and accounted for the relation between the firm and the loose iron by the supposition that the fall of the meteor had taken place when the basalt was forming, which is thought to have occurred in the Miocene period.

Dr. Nauckhoff who, in his capacity of geologist, accompanied the expedition sent out by the Swedish Government in 1871 to Greenland in order to bring home the loose iron-masses, did not venture to pronounce any opinion on their origin, particularly because nickel-iron had not yet been seen in any telluric rock.§ By the manner in which he explained the results of some of his analyses, he contributed however to render the question more complicated, as he believed to have found in the basalt, besides the metallic iron, Troilite and dumpling-shaped portions of Eucrite,

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* In the literature this place is called Ovifak, but ought without doubt to be written Uifak, as we must suppose it to be connected with "uiariak, I, you, shall go outside" (see the Greenland dictionary of Kleinschmidt). With Uivfak, a fern, it has nothing in common.

† Kgl. Sv. Vetensk. Akad. Förh., 1870, p. 1067.

‡ In for instance Quart. Journ. of the Geol. Soc. of London, Vol. XXVIII. page 44; and Post-och Inrikes-Tidningar, 1871, Nos. 255 and 260, and 1872, Nos. 110 and 111.

§ Bihang. t. Kgl. Sv. Vet. Akad. Handl., Vol. I. No. 6, p. 35.

respectively a mineral and a kind of rock especially characteristic of meteorites.

These views were approved of by Nordenskiöld, who now adopted the notion that the meteoric fall had consisted of Eucrite, with balls and grains of metallic iron.*

This view was generally approved of, for instance by Wöhler, Daubrée, and Tschermak;† because it was also to them decisive that metallic nickel-iron had never yet been found in any telluric rock.

On the news of this remarkable discovery Professor Johnstrup, who immediately saw its great importance, obtained, through the instrumentality of our Ministry, the permission of the Swedish Government for a Dane to accompany the above-mentioned expedition in 1871, and by an order of the 4th May of the same year the Ministry for Ecclesiastical Affairs and Public Instruction intrusted me with the performance of this task. Professor Johnstrup, indeed, thought it necessary to examine the facts at the spot itself, before the loose iron blocks were removed, for he considered that these belonged to the rock upon which they were lying, and that, consequently, they were not meteorites. I also came to the conclusion that the manner in which the iron was lying in the basalt allowed but of one explanation, viz. that it belonged to the latter in the same way as every other mineral belongs to the rock in which it has been formed; and that the loose iron-blocks were boulder stones.‡ If this explanation had been applied to any other mineral, nobody, of course, could have had the slightest objection to it, and the question would only have been in what manner the substance had been formed. Now, on the contrary, the fact that the iron-blocks had a shape and a structure corresponding to those of meteorites was regarded as a "proof" that they must have a meteoric origin.

I, however, immediately saw that their shape could be of no moment, and that chemical analysis could not decide the question; for we had, indeed, to deal here with a new telluric mineral, and however much the structure might resemble that of meteoric iron, this circumstance would have no weight; for no one has ventured to maintain that such iron could not be of telluric origin, and this would certainly be the only just foun-

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* Post-och Inrikes Tidningar, 1872, No. 111.

† Wöhler, Göttinger gelehrte Anzeigen, 1872. Daubrée, Comptes rendus, LXXIV., LXXV. and LXXXIV. Tschermak, Mineralog. Mittheil., 1874.

‡ Vidensk. Meddelelser fra den Naturh. Forening i Kbhvn, 1875, p. 295, and Min. Magazine, Vol. I. p. 143.

dation for such a "proof." However, as long as the assertion that any "nickeliferous metallic iron, not being an artificial product, must be meteoric iron" remained unshaken, it was impossible to advance the other view, and my efforts were therefore directed to finding such iron at other places in the basalt, and under such circumstances, as would admit of no doubt as to its telluric origin.

When therefore next year Professor Johnstrup obtained a grant for me to return to Greenland in order to follow up this question further, I examined the basalt at as many places as possible, after first visiting Blaafjeld. At first it seemed that I should not succeed. I nowhere found metallic iron in the basalt, and only at one place, at Asuk in Wajgat, did the boulder-stones give signs of it, but I found no iron in them. When coming home, I saw this question before me quite as insoluble as in the preceding year. Then I began the microscopic examination, and in the preparation No. 17 I had the good luck to discover small grains of metallic iron in a basalt of a peculiar aspect from Asuk in Wajgat, of which I, unfortunately, had in a hurry taken but one sample, without much noticing the mode of occurrence. I then examined more than 200 basalt preparations from more than 40 different places in North Greenland; but in no other, the basalt from Blaafjeld of course excepted, could I discover metallic iron, though several of them precipitated copper. The Professor, Dr. Jörgensen, had the kindness to examine the iron-grains from Asuk, and found that they contained traces of nickel and cobalt. Consequently, the aim was nearly reached, for here metallic iron was for the first time discovered in the basalt, the single grains being visible to the naked eye, and containing those elements which were thought to be peculiarly characteristic of meteoric iron. I had also the satisfaction to find that with respect to this discovery, Rammelsberg declared it to be most probable that the iron masses of Nordenskiöld must be considered of telluric origin,* and he adds that the presence of nickel alone will hereafter not be sufficient to stamp a loose iron block as a meteorite.†

One of the few who from the beginning objected to considering the iron masses of Nordenskiöld to be meteorites, Professor Lawrence Smith, in North America, has lately performed a very careful analysis of the rocks and minerals concerned;‡ and after showing the erroneous interpretation of Nauckhoff with respect to the Troilite and Eucrite, which are simply

* Zeitsch. d. deutsch. geolog. Gesellschaft, XXVIII. p. 225.

† Abh. der Akad. d. Wissenschaften zu Berlin, 1879.

‡ Annales de Chimie et de Physique, XVI. 1879.

magnetic pyrites and dolerite, he proves in how many ways Nordenskiöld's iron differs from meteoric iron, its sole claim to be so considered only consisting in its containing nickel; for, he adds: "Il ne faut pas perdre de vue que l'on ne possède pas, jusqu'ici, de fer natif terrestre authentique en masses auxquelles nous puissions comparer les blocs groënlandais; . . . mais, si nous admettons que le fer d'Asuk est d'origine terrestre (et je ne vois pas comment la chose peut être douteuse après la description du gisement donnée par M. Steenstrup), la présence du nickel et du cobalt perd une grande partie de sa signification, car nous avons vu que ce fer en renferme."* Daubrée, too, who, as above said, was at first much inclined to consider the iron masses of Nordenskiöld as meteorites, has, after the publication of this treatise, abandoned his former view.†

At the invitation of Nordenskiöld, Dr. Törnebohm made a microscopic examination of the rocks Dr. Nauckhoff had brought home from Blaafjeld,‡ and like Lawrence Smith, he rejected the Troilite and the Eucrite. On the other hand, partly on the basis of the analyses of Nauckhoff, he mentioned a new kind of rock, Anorthitfels, consisting of Anorthite with Graphite and the red-violet mineral which, according to Nauckhoff, is spinel, according to Lawrence Smith, corundum. As to the iron, he only ventures to speak about the iron-grains which are only large enough for a microscopic examination. In his opinion, they appear, together with magnetic pyrites and the mineral that resembles hisingerite, as later interstitial minerals in a large grained basalt, which, on the other hand, together with "Anorthitfels," is found in a breccia-like manner imbedded in the basalt. The small iron grains, he thinks, originate from the circumstance that the basalt, by its eruption, has melted a bituminous rock, containing lime and clayey soil, which by that means has become Anorthitfels, and the bitumen of which has then later on reduced some iron-solution. These iron-grains are consequently of a telluric origin, and though he does not attempt to prove any difference between the iron in these small grains and that in the large masses, he dares not pronounce any judgment about the origin of the latter. Yet he adds: "In dem Laboratorium der Natur dürfte indessen der Unterschied zwischen der Hervorbringung einer Kugel von der Grösse einer Erbse oder einer solchen von zwei oder drei Kubicmeter Inhalt wohl nicht als besonders wesentlich angesehen zu werden brauchen."§

* Annales de Chimie et de Physique, XVI., 1879, p. 491.

† Comptes rendus, LXXXVII., 1878, Séance du 9 Décembre.

‡ Bihang. t. Kgl. Sv. Vet. Akad. Handlingar, Bd. V. No. 10.

§ Bihang. t. Kgl. Sv. Vet. Akad. Handlingar, Vol. V. No. 10, p. 17.

As a matter of course I very much wished once more to be able to examine the ferriferous basalt at Asuk, and when the Board for the Geological Examination of Greenland in 1878 gave me the charge of investigating North Greenland, my wish was gratified, though it was only in the summer of 1880 that I arrived at this remote place.

In the autumn of 1879, however, I had made a discovery in connection with this matter, for in an old Greenland grave at Ekaluit, at Ikerasak in Umanaks-Fjord, I found 9 *pieces of basalt containing round balls and irregular pieces of metallic iron.* These pieces were lying together with knives, similar to those brought home by Ross, as well as with the usual stone tools, for which latter the raw materials were found in pieces of rock-crystal, chalcedony and Lydian-stone, whereas the 9 pieces of basalt with the iron balls were evidently the materials for the bone knives. This iron is soft and keeps well in the air, from which reason it is fit for use in the manner described by Ross. The rock in which the iron appears is a typical, large-grained felspar-basalt, and this discovery has a double significance, firstly, because it is the first time we have seen the material out of which *the Esquimaux made artificial knives* before they got iron from the Europeans, and secondly, because it showed *that they have used telluric iron for that purpose*, so that the supposition that they used meteoric iron* falls to the ground, for that only depended upon the belief that all metallic nickel-iron had a meteoric origin. It is, therefore, a matter of course that the blocks, from which the material of Ross's knives has been taken, must from this moment, at least until they have been subjected to a more searching examination,† be considered as being more probably telluric than meteoric iron. Futhermore, this discovery also throws a light on Rink's iron from Fiskernæs,‡ and, perhaps, on that brought by Giesecké from Arveprindsens Eiland,§ being, like the former, malleable,

* Ross, Voyage of Discovery . . . . of North-West Passage, London, 1819, p. 98, and LXXXIX. The Edinburgh Phil. Journal, Vol. I., 1819, p. 154. Silliman, American Journal of Science, Vol. 42, 1866, p 249. Compte rendu du Congrès international d'Anthropologie et d'Archéologie préhistoriques, Bruxelles, 1872, 6me. Session, p. 242.

† Christian VIII. caused in the years of 1840-50 two expeditions to be equipped for the purpose of looking for these iron masses, one on dog sledges, and one in boats; but no result was obtained, the former only going a few miles from Upernivik, and the latter not even setting out.

‡ Rink got this iron, among other minerals, from a Greenlander. It resembles very much the iron from Ekaluit, and is the same piece which Forchhammer mentions to have received from Motzfeldt. (Lütken Almeenf. Naturskildringer, I. p. 220, Note.)

§ Of this iron we know nothing but what is written in Giesecké's MS. Catalogue: "Ein zerfressenes Stück (gediegen Eisen ?) gefunden in einem Torflager auf Arveprindsens Eiland."

nd keeping well in the air. That the iron from Fiskernæs has been found o far from the trap-territory is easily explained in the same way as the ieces of bell-metal which are found along the coast through all North reenland, that the Esquimaux, on their frequent voyages, have carried it ith them, and it may perhaps, like the iron from Ekaluit, at some time or ther have come from a grave.

Finally, the iron found at Ekaluit is also of importance from the reason at it affords testimony of the old graves of the Esquimaux being used for e storing of telluric iron. Yet it cannot be of frequent occurrence there, as would else scarcely have escaped the eyes of the many persons who have ught for antiquities in the graves, however easily it may be disregarded; r even I myself, who am so accustomed to look for metallic iron, have only und it in this one grave, though I have examined several hundreds.

Everybody who knows the manner in which the Esquimaux form the mes of localities, must see in Ross's name Sowallick (Savilik) an timation with respect to seeking places where metallic iron is to be ind. Thus Kleinschmidt, in his Greenlandish Dictionary, has already entioned names which allude to it, and, after the discovery at Ekaluit, I not doubt of success in that direction. I have had myself only an portunity to make investigations at one of these places, say at Saviorkat, the post of Niakornak in Umanaks-Fjord; but the time was so very short, d the weather so unfavourable, a thick fog with showers prevailing during my stay there, that my search was performed just as if I were ndfolded, therefore the negative result I obtained is of no importance atever. Although a search in such places might be interesting and, thout doubt, also accompanied by success, it is still, after my later dis-veries, of less importance, for in the summer of 1880, without this e, I succeeded in discovering nickel-iron in solid basalt at several places the coast of Disco. The first of these was Asuk.

As above mentioned, I brought from thence in 1872 the piece of basalt that as found later to contain metallic iron, but without noticing the existence of as I had no idea of its importance, and I therefore found it a little difficult discover the place again. However, I was convinced that if I could dis-ver the place where I then had pitched my tent, I should certainly also find e basalt. I had therefore secured the same coxswain of the woman-boat *miak*) who then accompanied me, for, confiding in the faculty of the reenlanders to find out localities, I was sure he would be able to recognise e site of my tent. Unfortunately, however, he could not find it again, d therefore brought me to a place six miles too far to the east; on that count I lost some days in looking for the right place, and having at

last found it, I could scarcely, for want of provisions, remain there for 24 hours. The place is, however, easy to be recognised, being where "Asukhouse" has stood; nay, this house has even been built of the ferriferous basalt, just as the tent walls near Ivigtut were formerly built of cryolite. Fig. 1 shows the stratification here. At the base

Fig. 1. (R. Hammer.)

at the surface of the water, to the left, are to be seen the coal formations, *a*, in a slope about 20 feet high. Above these is a peculiar mass, *b*, resembling tuff, and consisting of a mixture kneaded together of basalt-tuff and a partly hardened and modified clay-slate containing sand. On this rests a stratum of basalt, about 50 or 60 feet thick, *c*, shaped in magnificent columns, among the finest I ever saw in Greenland, and thereupon follows at last the *ferriferous basalt*, *d* (the bed seen above the tents), with a thickness of about 50 feet. The whole slope is about 120 feet high, and the strata dip about 10 degrees in the direction of the coast towards north-west. The limits towards the columnar-basalt below can easily be seen as they are very sharp,* but I did not succeed in discovering the upper boundary; the reason of this, however, was certainly only want of time. *This peculiar layer of basalt is filled from top to bottom with iron-grains* of all sizes, from the fraction of a millimeter to a length of 18 mm. with a breadth of 14 mm., which is the greatest I have found. Yet the larger balls do not consist entirely of iron, for they seem to be an aggregate of smaller grains grown together, a section through them reminding one of the structure shown by the Mesosiderites. When polished this iron shows beautiful Widmannstätten figures, which fact, consequently, proves the truth of my supposition set forth in my former paper, that if we succeeded in finding larger blocks of telluric iron, we should also find

* But only seen with the naked eye; for in microscopic preparations, exhibiting both varieties, one sees how the fluctuating structure by which the ferriferous basalt is in so high a degree distinguished, passes into the granular structure of the columnar-basalt and effaces the limit.

these figures in it. In the same paper I directed attention to the occurrence of graphite together with the iron, and this time I found here in the basalt a considerable amount of this mineral as well as of the graphitiferous felspar (the "Anorthitfels" of Törnebohm) found at Blaafjeld. Also in the basalt from Ekaluit there was graphite together with the pure iron.

The next place where I found a solid ferriferous basalt is *a neck of land on the northern side of the mouth of Mellemfjord, on the western side of Disco*. Already at Napasuligsuak, in the north of Nordfjord, I had found boulder-stones of the basalt, but neither there nor in this whole fjord did I find it *in situ*. The neck of land at Mellemfjord we called "Jernpynten," because it, having a breadth of about the quarter of a Danish mile, proved to consist almost entirely of this rock. Yet this is only true with respect to the extremity of it; for some hundred feet inside we find an ordinary large-grained basalt (Doleritporphyr), and only at a distance of about 4,000 feet we again discovered the upper part of this layer on the slope of the rock in a height of about 540 feet. The lower boundary I could not determine, on account of downfallen masses and of vegetation. This description, however, only refers to the southern side of the neck of land; on the northern side, the large-grained basalt is found quite out to the extremity, but immediately within there the ferriferous basalt stands firmly in a slope about sixty feet high, and also forms a couple of rocks lying a little northward to the isthmus. Seen from the southern side of Mellemfjord the layers in the rocks dip here about eight degrees towards west, which fact also corresponds with the circumstance that after the interruption the ferriferous basalt is only met with at a height of about 550 feet, and that the angle from there to the isthmus was measured to be eight degrees. How great the thickness of the layer is I cannot tell, but I estimate it at about 100 feet. When we walk higher up the slope of the rock that for a part is overgrown, we again meet with it in a height of 950 feet. The angle from here to the isthmus is 9¼ degrees. Above, there lies a red amygdaloid, and higher upwards I could not find the layer either *in situ* or in loose pieces.

The ferriferous basalt here resembles generally that from Asuk, as well in hand-pieces as in microscopic preparations, yet at several spots it approaches the appearance of a small-grained basalt. The manner in which the iron appears is quite analogous to that at Asuk; and here too graphite and graphitiferous felspar are to be seen, partly in sharp-edged pieces, partly in concretion-like excretions.

About one and a half Danish miles further up the Mellemfjord, I found near some remnants of a house, in the steep bed of a river, a considerable number of large, sharp-edged blocks of the ferriferous basalt. The stratum to which they belonged I could not find or reach, the bed of the river being yet full of snow and ice; but their being *in situ* is not to be doubted, for the pieces looked as fresh as if they had lately fallen down.

Furthermore, ferriferous basalt is found *in situ* in *a ravine on the northern side of the inner part of Mellemfjord*, in a height of 800 feet. Here the iron was to be seen partly secreted in the basalt-mass itself, partly filling the cavities of pores in connection with magnetic pyrites. Here too are seen both sharp-edged pieces and concrétion-like secretions of graphite and graphitiferous felspar. The basalt is partly as small-grained as at Asuk, partly large-grained, and then is not to be distinguished from the common dolerite. The iron shows on being polished and etched beautiful Widmannstätten figures, and contains, according to an analysis which Professor Dr. J. M. Jörgensen has been kind enough to perform, 2·69 per cent. of nickel. It is soft and malleable, so that it can easily be hammered into plates thin as paper, and shows, like the iron at the above mentioned places, plane cleavages (after the octahedron ?) with a strong tin-white lustre that remains unchanged for months.

Once more I found ferriferous basalt *in situ*, viz. on the southern side of Mellemfjord at Ivigsarkut, where it closely resembles common basalt; it has, however, partly a lava-like aspect.

On the rock in the east thereof, the loose stones, on the slope to a great extent overgrown in a height of about 1,350 feet, also consisted nearly exclusively of ferriferous basalt, so that the layer must there also be firm. As on the northern side of the fjord, the strata dipped about six degrees outward, towards north-west.

Metallic nickel-iron with Widmannstätten figures has now been proved to be also a telluric mineral, and the presence of nickel together with a certain crystalline structure are consequently not sufficient to give the character of meteorites to loose iron-blocks, so that the view put forth by Professor Johnstrup in 1871,* in opposition to the "meteoric iron" of Nordenskiöld, has been proved to be right.

The places where metallic iron is found in North Greenland, the number of which has now been considerably enlarged, are marked on the map† with Fe and (Fe) respectively, when the iron has been found *in situ*

* Communicated in "Vidensk Selskab," the 26th Jan. and 9th Feb., 1872.

† Not given with this Paper.

or only in loose blocks. Without entering upon details with respect to the chemical composition, an account of which will be given in the following treatise by Mr. J. Lorenzen, I shall only here observe that *there seem to be two kinds of iron*, one being hard, brittle, and easily weathered, containing a greater quantity of carbon, which we with Forchhammer may call *meteoric cast iron*, to which belongs the iron from Niakornak, Jacobshavn, Fortune Bay, Blaafjeld, and, perhaps, Arveprindsens Eiland (Heir Apparent Island); and another, *meteoric wrought iron*, being soft, malleable into thin plates, for a greater part resisting the influence of the atmosphere, and only containing a small quantity of carbon, to which belongs the iron from Sowallick (Savilik), Fiskernæs, and all that I have found. The latter kind of iron, which resembles real meteoric iron more than the iron from Blaafjeld does, will undoubtedly prove a curious material for comparison in the study of meteorites, and we shall now see if in a chemical way any difference can be detected between meteoric and telluric nickel-iron.

In my former treatise I tried to maintain that the manner in which the iron appeared in the basalt at Blaafjeld* *could only be explained by its being formed in it*, and this notion has also been fully approved of by Lawrence Smith and partly by Törnebohm, as far as those iron-grains which are not larger than are fit for a microscopic examination. The reason why Dr. Törnebohm does not venture to go further, is evidently the same that made Nauckhoff, Tschermak and Daubrée doubt the telluric origin of the iron-masses of Nordenskiöld—I mean the fact that such iron had not been found elsewhere; but this objection now being removed, I do not doubt that he too will give up his reservation. The peculiar breccia-like structure the basalt has at Blaafjeld *there* where it encloses the iron, caused Nauckhoff to suppose that there were lumps and dumpling-like parts of other rocks in a common basalt, but while his description particularly suggested the supposition that these rocks were derived from outside, as also Nordenskiöld has understood it, Törnebohm represented the matter as if a dolerite and his "Anorthitfels" were carried up as fragments with the basalt. I, too, immediately saw this breccia-like structure; but as to the Anorthitfels, I considered it to be porphyritically secreted lumps of a graphitiferous felspar, and the large-grained parts (the dolerite of Törnebohm) I thought to be a variety of the common

* According to Dr. Törnebohm, my notion that the iron is here found in a layer and not in one or two dykes has now been acceded to by Professor Nordenskiöld. L. c. p. 4. See also Nordenskiöld: "Studier och Forskningar," p. 210.

basalt, which, on account of peculiar circumstances being at work, has got a somewhat different aspect, and has probably also during the formation been subject to great changes of volume that have produced smaller veins. It is moreover difficult to observe matters at the place, partly on account of the quantity of weathered iron crossing the basalt (so that each fragment is surrounded by a coating of rust), and partly on account of the large loose stones covering the shore and thereby preventing a systematical investigation. At any rate, a breccia-like aspect, as well as concretion-like secretions, are no very rare features in the basalt; but expatiating upon this would here lead me too much astray, the more as I hope later to return to this subject in a statement of my researches on the basalt in North Greenland, generally speaking.

When we proceed to examine the relations in which the iron appears at the other places, though they are easier to be overlooked there, because the blocks of iron are smaller, yet, as at Blaafjeld, we also everywhere meet graphite and magnetic pyrites together with the iron, the graphite being found partly in the basalt as small lumps, partly penetrating a triclinic felspar in connection with the same small red-violet grains as at Blaafjeld. This felspar appears either as single porphyritically secreted crystals or as concretion-like secretions.

In my first treatise I directed the attention to the fact that the ferriferous basalt at Asuk had a peculiar aspect; but it was, however, not my meaning that it should not be considered a basaltic rock, even if it be not a typical basalt. This view has been confirmed by my later discoveries; for however peculiar it may look in general, yet it shows in Mellemfjord *such complete transitions to common basalt* that it is evidently but a variety which we might characterise as *iron-basalt*. The iron appears here in three ways:—(1) partly as small, drop-like particles equally distributed throughout the whole mass, as it is in a typical way at Asuk; (2) partly as sharp-edged grains grown together, with a tin-white lustre at "Jernpynten," and partly in Mellemfjord; and (3) finally, filling out pores in connection with magnetic pyrites, as in the inner part of Mellemfjord.

Not only is the graphite a steady companion of the iron, but this mineral is also to be found at several places in the basalt where the iron is not visible, at least not to naked eyes, partly as small round balls; thus, in a dyke of basalt at Kook Angnertunek, on the southern side of Upernivik's Island in Umanaksfjord (Fig. 2, p. 13), and in a dyke of basalt at Nuk in Waigat, and partly quite penetrating the basalt, so that we are entitled to speak of a *graphite-basalt*. Such a rock, graphite-basalt, appears in a great bed in the steep inaccessible rocky wall above Nuk,

n Waigat (and there it also contains microscopic iron-grains); further-
nore, at Nungerut, near the coal mine of Ritenbenk; and, judging from
ne boulder-stones at Asuk, also perhaps at the north-western extremity of
Disco; and, finally, it is found *in situ* at Nordfjord.

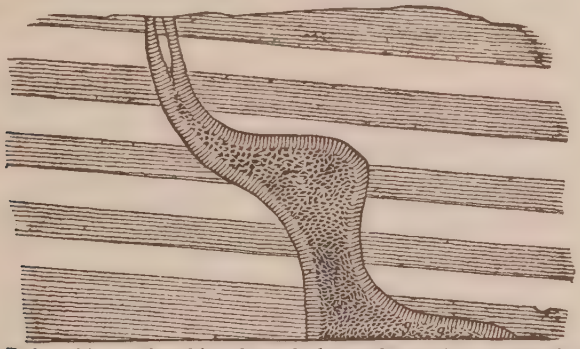

Fig. 2.—Dyke of basalt breaking through the coal-containing formation (slate, the
ped compartments and sandstone) at Kook Angnertunek. Towards the side the
salt is separated in columns, and at *g* it contains round lumps of graphite as large
peas.

Here it is to be mentioned, too, that the basalt on the northern side of
e large Bay of Kasigisat, between Nord- and Mellemfjord, contains
rge concretion-like lumps of graphitiferous felspar, much resembling
nded fragments, and, perhaps, also being so.

However there may be a difference between the manner in which the iron
ppears at Blaafjeld, and that in which the one or the several ferriferous
salt layers appear along the northern and western coast of Disco, where-
re, perhaps, we may be inclined to make the following inference:—

Of course the iron in the basalt layers is telluric, but the large iron-
sses at Blaafjeld, which appear only in a much limited region, are, as to
eir aspect and size, so essentially different therefrom, that we cannot
ink them formed in the same manner, and so they may, perhaps, be
teoric; however that may be, I must, in the first place, be permitted to
fer to the *mass of magnetic pyrites in the dyke of basalt* at Igdlokunguak,*
ich is quite as large and shows that masses of a similar size can be
rmed in the basalt, or can, at any rate, be carried up with it; and, in
e second place, I must refer to the fact that nickel-iron with Widmann-
itten figures now *has been proved to be a telluric mineral*, the want of
idence of this fact, according to Lawrence Smith, being the only ground
considering the iron-masses of Nordenskiöld to be meteorites; for in all
ner respects real iron meteors were, indeed, very dissimilar from them.

* Vidensk. Meddelelser fra den naturh. Forening i Kbhvn, 1875, p. 304.

II.—*A Chemical Examination of Greenland Telluric Iron.*

By Joh. Lorenzen.*

(Translated from Meddelelser fra Grönland. Heft 4. 1883.)

WHEN in 1870 Nordenskjöld had made the discovery at Blaafjeld (Ovifak) on the Isle of Disco of the remarkable large iron blocks, there soon, as will be remembered, arose a whole literature on the occurrence and origin of this iron. Although the Danish naturalists had, from the first raised a series of objections against the theory of the meteoric origin of these iron-blocks, the problem of their existence could not be satisfactorily solved without careful geological investigations having been first made into the nature of the whole of the Greenland basalt-formation. Such investigations having been made by Mr. K. J. V. Steenstrup, I was directed by the Danish Commission for the Geological and Geographical Survey of Greenland to make a chemical examination of the materials collected. The following is a report of the examination thus undertaken, which, however, was not confined to the rich collection brought home by Mr. Steenstrup, but has been extended to a number of specimens of iron preserved in the Museum of the Copenhagen University. These have been found in Greenland at different times since the beginning of this century, but only a few of them have been hitherto accurately described, although they may, most of them, have been mentioned, incidentally at least, in some work or another. With the specimens in question so many problems are connected, that I have thought it proper to confine —previously at least—the object of my examination to the two most interesting ones. The first question which arises is that of the native iron itself, and also to a certain extent that of the basaltic rock. The second question concerns the graphitic felspar, the "Anorthitfels" of Dr. Törnebohm,† which constantly occurs with the iron. I have not examined the pyrrhotite and the chlorophæite, these being of less interest. As long as the point of issue was the possibility of the iron being meteoric, the occurrence of the pyrrhotite was more important than it is now, especially because it was taken for Troilite, owing to an incomplete analysis made by

* Dr. Lorenzen died on the way to Greenland, the 5th May, 1884.

† Bihang t. Svenska Vet. Akad. Handl., Vol. 5, 1878, No. 10, p. 14.

Dr. Nauckhoff.* Now, however, as Mr. Steenstrup† and later on Prof. Lawrence Smith‡ have proved the accordance between the pyrrhotite of Blaafjeld and that of Igdlokunguak, and as the telluric origin of the iron has been indisputably established, this matter is placed more in the background.

Before proceeding to the detailed description of the iron, I shall make some remarks with regard to the manner in which the analyses have been made.

As a rule the iron was dissolved in hydrochloric acid, in some few cases in *aqua regia*. The solution evaporated, the dry residue was dissolved as usual by means of a little diluted hydrochloric acid. In the solution the copper was first determined; then the iron was separated from nickel and cobalt by ammonium carbonate after the method of Lippert, as given both in Rose's and in Fresenius's works on quantitative analysis. If only so much ammonium carbonate be added, that a little iron is still in the solution after precipitation, this method is very excellent. The small amount of iron remaining was precipitated by ammonia in excess and added to the first precipitate. This operation was repeated several times in order to extract all the nickel and cobalt, but experience shows that in most cases two precipitations, if well made, would have been sufficient. In the two first analyses the nickel and cobalt were weighed in the form of metals, in the others in the form of sulphates. When dissolved, the iron always left a residue, which naturally was a little attacked by the acid, and it must therefore be expected that a little alumina, iron-oxide, lime, magnesia and silica, perhaps also alkalies, would be found in the solution. As none of these substances has anything to do with the composition of the iron, I have not determined any of them but the silica and alumina. It also ought to be remembered, that the quantity in which they are present in the solution depends upon quite casual circumstances, such as this, whether a more or less diluted acid be used, &c. Moreover, it would have been very troublesome to determine the lime and the magnesia on account of the large amount of salts of ammonia which by applying the above method had been accumulated in the solution.

Phosphorus was searched for in all the analyses, by applying the method described in Fresenius's Quantitative Analysis, 6th edition, II. p. 434. As Dr. Törnebohm by means of a combined microscopical and chemical investigation has found Schreibersite in the Blaafjeld iron, I was rather as-

* Bihang t. Svenska Vet. Akad. Handl. Vol. I. 1872, No. 6.

† Videnskabelige Meddelelser fra naturhistorisk Forening i Kjöbenhavn 1875, 284.

‡ Ann. de Chimie et de Physique, 5te série, t.XVI. 1879, pp. 452-505.

tonished at not being able to detect any trace of phosphorus in any one of the specimens analysed, except in the Niakornak iron, where its presence had already been stated by Forchhammer and Lawrence Smith. It ought, however, to be remembered, that the amount of the other constituents of the iron-pieces is somewhat varying. In searching for the phosphorus, as a rule, I used 5 to 6 grs. of the iron.

Sulphur was determined by dissolving the iron in *aqua regia*, and evaporating to dryness, whereupon the residue was dissolved in a little hydrochloric acid, and the sulphuric acid precipitated by barium-chloride.*

Carbon was determined by the method of Ullgren (described both in Fresenius and in Rose); the iron was dissolved in sulphate of copper, and the remaining carbon was oxidised by chromic and sulphuric acid, and weighed as carbonic acid.

Chlorine was not determined, although present in small quantities in all the iron specimens, as appears from the iron chloride oozing out on almost every piece of iron. But this examination would form a part of an investigation of all the soluble salts contained in the iron, which my time has not yet permitted me to undertake.

I have not examined iron from all the new localities, but only from those that are somewhat abundantly represented in the Copenhagen museum. The following account first describes the iron from the chief locality, Blaafjeld (Ovifak, or more correctly Uifak); then that found in three other localities on Disco island, viz. at two different places in the Mellemfjord on the west side—and at Asuk in the northern part of the island, which latter place has obtained a peculiar interest, as it was the first place after Blaafjeld where Mr. Steenstrup succeeded in finding iron *in situ*. Then follows the description of the loose blocks, all of which have, with perhaps one exception, been imbedded in the basalt; and of the remarkable iron taken from the Greenland grave at Ekaluit. To the examination of the last is added an analysis of Greenland wrought iron, viz. two knives, the material for which must have been taken from the basalt.

Lastly follows an examination of the *graphitic felspar*, taken from two of the many localities.

I. IRON IN SITU.

A. Blaafjeld. (Ovifak=Uifak.)

Under this heading I also include the loose blocks which have been found on the shore at "the iron locality," because they also have once been

* Rose. Handbuch d. Anal. Chemie. II. p. 563.

imbedded in the basalt. It is well known that investigations have been made with regard to this iron by many chemists, as Nordenskjöld, Nordström, Nauckhoff, Wöhler, Daubrée, and Lawrence Smith, all of whom have given their opinions on the now settled question of its telluric or cosmical origin.*

Several of these investigators have attempted to make out different types of iron, which at the first sight seems very natural, but further examination shows that nearly every new piece of iron may be taken for a new type. If the types which the different investigators have set up be compared, the identification of them also will be found a very troublesome work. Really all transitions may be found. As an instance of this, may be mentioned that metallic iron is found in the form of small grains imbedded in common dolerite, and that grains similar to these are also found imbedded in a soft green mass, which latter is found in some of the blocks lying on the shore. A fresh fracture of this rock affords an exceedingly beautiful aspect, when the silver-white shining iron grains are seen disseminated in the fine green ground-mass. This aspect, however, lasts only a short time; after a few minutes the grains become already somewhat dim, and after some days we see only a spotted grey-brown mass with a few metallic points. These latter are more durable; some fragments of the rock in question were kept in a closed glass for more than half a year, together with a small cup filled with concentrated sulphuric acid, and at the end of this time the metallic points still retained their original appearance. While in the cases just mentioned, the dolerite or the green ground-mass was absolutely predominant, we, on the other hand, find other specimens in which the iron and the basalt are almost equally developed, or where the iron is beginning to prevail. The analyses given under No. 3 were made on fragments taken from such a block. Before the block was broken to pieces, it looked very firm and strong, but nevertheless it was very easily crushed with the hammer. It appeared that the interior was composed of a soft mass, which when pulverised and sifted, might be separated tolerably well into grains of iron and a brown powder, which latter evidently owed its origin to decomposition. The grains of iron could not be further powdered, and were a little malleable. On the outside, the loose mass was encompassed by a firm crust, intermixed with basalt. I think that

* Since the above lines were written in Danish, a new paper by Nordenskjöld has appeared, wherein this matter is discussed from quite a new point of view, the correctness of which, however, the author cannot admit; but it would take too much space to enter on a further discussion of it here.

some of the bigger blocks are of this kind, as both Daubrée and Lawrence Smith state that the blocks examined by them when sawn through were found to consist of a firm crust around a loose interior. Further, a whole series of transitions are found between these blocks, and those specimens which consist almost entirely of metallic nickel-iron. Of these last No. 1 and partially No. 2 below are examples. It is true that such hard, firm and tough masses of iron present an appearance quite different from that of the grains that are found in the manner above described, disseminated in the basalt, or in the remarkable green ground-mass. But in fact a difference between the two is to be found only in the amount of the iron present. It appears as if the iron had originally been deposited at many points, and being still in a fluid state had in some places accumulated to form greater masses. It is an interesting fact that both malleable and cast iron has been produced; at Blaafjeld both forms occur, while at the other localities only the malleable iron is found. I have not analysed the Blaafjeld malleable iron, but Mr. L. Smith has made an analysis of the same,* the result of which agrees very well with one of the varieties examined below. No. 1 again, as well as several specimens that have on former occasions been examined by others, belongs to the form which may be considered as natural cast iron.

As is well known, there is still a peculiarity on which a distinction might be founded, I mean the aptitude so characteristic of many specimens of this iron to crumble when preserved in a museum, while it stands the open air much better. As a contrast to these might be set up some other specimens, for instance No. 1, and some parts of No. 2 below, which consist almost entirely of metallic iron, and may be preserved in a museum without the interior of the same being damaged. Further also, the grains mentioned above that are found imbedded in the basalt do not seem to lose any of their original fresh lustre.

No. 1.—A piece of iron of the size of a large fist, oblong, flat on one side, and round on the other side. Fracture granular, silver-white when quite fresh. The iron very hard and tough; cannot be crushed with a common hammer, but only with a steam hammer. Very difficult to bore even with the hardest tools. On the whole very pure, only in a few places enclosing some of the rock. No difference between the exterior and interior parts; the boring was done in the interior. The iron excellently durable. It had been lying for a long time on a flat roof exposed to rain and sunshine, and after having been broken to pieces, it has been

* l. c. p. 465.

kept in the dry air of the museum, without suffering any damage under these very different conditions.

The specific gravity of a small piece weighing 2·6185 grs. was 6·87 at 20° C. The chief analysis was made on 2·471 grs.

Results of the analysis :

Cu	0·16
Fe	91·71
Ni	1·74
Co	0·53
S	0·10
C	1·37
SiO_2	0·31
Al_2O_3	1·21
Insol. in HCl	2·39
	99·52

Phosphorus could not be traced in 6½ grs. of iron. The determination of carbon is the mean of two analyses, which gave 1·35 and 1·38 respectively.

No. 2.—A flat slab, which when broken to pieces showed in some parts a similar green mass to that mentioned above, but in other places pure, silver-white iron, with foliated fracture, and fine cleavage faces. This piece had formerly resisted the influence of the weather in the open air very well, but is now partially altered on account of its being preserved in the museum. The parts consisting of pure iron are those best able to resist, and these show on fresh fractures the fine silver-white lustre.

Composition of the iron :

Cu	0·16
Fe	91·17
Ni	1·82
Co	0·51
S	0·78
C	1·70
SiO_2	0·46
Al_2O_3	2·12
Insol. in HCl	0·77
	99·49

The chief analysis was made on 2·716 grs. Phosphorus not traced in 5½ grs. The determination of carbon is the mean of two, giving 1·62 and 1·78 °/° respectively. The great percentage of sulphur is striking as well as the large amount of dissolved alumina, while the undissolved residue is insignificant. This shows that the rock had been easily decomposed by the acids used.

No. 3.—The worn specimen mentioned above. One analysis was made on the altered interior (I.), another on the fresh exterior parts (II.). In both cases the metallic parts were tolerably well separated from the non-metallic ones. This was best effected by pulverising and sifting, on the altered interior parts. It was not possible to undertake a further separation by a magnet. To separate oxide of iron from metallic iron in the analysis seemed of no use, as the alteration had only reached a certain point, and an analysis made to-day might have given quite another result than one made a year afterwards. Because of the method also by which the iron grains had been isolated, the proportion found would have been quite arbitrary. Thus part of the metallic iron stated in the analysis must be taken to have been in reality in the state of oxide.

Composition of the iron :	I.	II.
Cu	0·19	0·23
Fe	82·02	59·77
Ni	1·39	1·60
Co	0·76	0.39
S	0·08	?
C	1·27	1·20
SiO_2	0·59	0·39
Al_2O_3	1·08	3·79
Insol. in HCl	8·03	22·23

The chief analysis was made on 2·539 grs. (I.), and 2·5705 grs. (II.).

The determination of carbon is the mean of two, giving 1·24 and 1·31 respectively. In the same analysis phosphorus was not traced in 5½ grs. In the second analysis made, phosphorus and sulphur were not searched for. As I obtained a much larger residue than I had expected in II., I determined the amount of silica therein, which was found to be 59·61 per cent. When the purity of the silica was tested, it appeared that it contained a small quantity of other elements. When it is taken into consideration that part of the alumina had been dissolved, it appears that the rock itself must have been considerably attacked by the acid, and the high percentage of silica cannot then be cited as an objection to the conjecture that the rock is a common basalt.

B. The Mellemfjord.

A. The Interior Parts of the Fjord.

I have examined the iron as well as the basalt from this new locality. This Iron like that next to be described is malleable, and all these specimens of iron present great similarity to each other. It is found in round and oblong grains usually of the size of a pea or a little larger. The larger grains often consist of smaller ones, which are welded together, as is very easily detected by hammering the grains flat. When the basalt is hammered, two or more pieces may often be kept together by the tough flexible iron. The iron is silver-white, very soft, and may in consequence of its extraordinary malleability be hammered into very thin plates, which very easily preserve impressions of the hammer and anvil. When hammering the grains I always saw small pieces of basalt falling out, which had been imbedded between the grains or in their cavities. The specific gravity therefore ought only to be determined on a flat and well-hammered plate; the grain before being hammered will always, even if the surface be filed quite shining, give too low a specific gravity. Mr. Steenstrup and I made the following experiments: a grain weighing 1·0045 showed a specific gravity 5·84, another one weighing 0·8885 gave 7·80. The first when hammered lost a considerable quantity of basalt, and this explained the low specific gravity. When the other grain was hammered, its specific gravity rose to 7·92. A third specimen equally hammered weighing 1·4955 grs. showed a specific gravity of 7·48. The high specific gravity depends upon the small quantity of the carbon contained therein, which circumstance also accounts for the iron being so malleable; and upon the small contents of nickel and cobalt.

I searched for phosphorus and sulphur in the same analysis in 4 grs. by the method given in Rose's Handbuch and Anal. Chemie. II. p. 503, but I was not able to detect any phosphorus. The chief analysis was made on 2·164 grs. Results of the analysis:

Cu	0·33
Fe	93·89
Ni	2·55
Co	0·54
S	0·20
C	0·28
SiO_2	0·46
Insol. in HCl.	1·48
	99·73

The Basalt.—From this place Mr. Steenstrup brought home iron that had been taken partly *in situ*, partly from loose blocks. The basalt found *in situ* is compact, and reminds one very much of the basalt of Asuk or that of the Jernpynt in the Mellemfjord. The loose blocks consist of medium grained dolerite. It is very interesting, that although we may find iron-grains of the size of a pea in the compact basalt, we also find much smaller grains, but in the dolerite large iron-grains only are found.* As the latter afforded more facility *for separating the iron from the basalt*, I chose the dolerite for the analysis, the results of which follow :—

SiO_2	53·01
Al_2O_3	15·85
FeO	11·53
CaO	8·72
MgO	7·51
Na_2O	4·49
	101·11

Some traces of manganous oxide and potash. The iron is given only as ferrous oxide, the two oxides not having been separated. Thus we have here a basalt with a percentage of silica a little higher than usual; but, apart from this, it does not present any difference from common basalt.

B. The Jernpynt in the Mellemfjord.

This occurrence shows a great resemblance with that at Asuk, as did also that last mentioned from the interior parts of the fjord. The basalt here is sometimes spotted in a similar way to that of Asuk, but it may also occur in the form of a fine-grained dolerite. What has been said on the manner in which the iron-grains are imbedded in the basalt found in the interior parts of the fjord, holds good here also. Still the iron is not so white and not quite so soft and malleable, on account of the larger amount of carbon contained therein. For the same reason, perhaps, the specific gravity also is a little lower. In one specimen of hammered iron weighing 0·9625 grs. I found the specific gravity 6·90 at 14°C., in another, weighing 1 gr., 7·57 at 14° C.

Results of the analysis :

Cu	0·48
Fe	92·41
Carried forward ...	92·89

* For this observation I am indebted to Mr. Steenstrup.

Brought forward	92·89
Ni	0·45
Co	0·18
S	Trace.
C	0·87
SiO_2	0·90
Al_2O_3	0·60
Insol. in HCl.	4·57
	100·46

Phosphorus and sulphur were searched for in the same manner as in the case of the iron from the interior parts of the fjord. The chief analysis was made on 1·674 grs. The determination of carbon is the mean of two giving 1·03 and 0·72 per cent. respectively. The materials were here separately selected for each determination of carbon. It is interesting to see how, with regard to the percentage of nickel, this iron makes a transition to the Asuk iron.

C. Asuk.

This was the first place after Blaafjeld where Mr. Steenstrup found iron *in situ*, and the locality has a peculiar interest, as it appears herefrom to be the most probable theory that all the "basaltic" iron had a telluric origin.* The iron found there was disseminated throughout the basalt in the shape of very fine specks, which could only be isolated by means of a magnet, after a very careful pulverisation. In the specimens, brought home later on, there are bigger grains, some of which attain the size of a hazel-nut. Yet most of them are rather small, smaller than those from the other localities, and if a biggish one is hammered one feels somewhat disappointed, seeing that a large part of it is the basalt, lying between iron grains, while the latter look as if they were welded together. The iron is silver-white, very soft and malleable; some hammered grains weighing 1·056 grs. afforded the specific gravity 7·26 at 12° C.

When crushing the basalt I collected some bigger and smaller grains, which were used for the analysis. As it was difficult to get much material, I did not determine the sulphur. The iron was dissolved in *aqua regia*, and phosphorus was searched for in this solution, but none was found.

* l. c., 1875, p. 296.

Results of the analysis:

Cu	0·14
Fe	95·15
Ni	0·34
Co	0·06
C	0·96
SiO_2	0·68
Al_2O_3...	0·51
Insol.	1·90
	99·74

Of all the iron found *in situ* or in loose blocks, this shows the lowest percentage of nickel and cobalt. Yet one of the Greenland knives mentioned below contains a still less amount than this. And at any rate we see that we ought to be very cautious in using the percentage of nickel and cobalt for determining whether loose blocks or Greenland iron tools are of "basaltic" origin or not; for if the proportion can be so low as we have here, we fail to see why it might not be still lower, or why nickel and cobalt might not perhaps be quite absent.

I have not examined the iron taken *in situ* from other localities, the material being so scanty that nothing could be spared for analyses.

II. LOOSE BLOCKS.

A. Arveprindsens Eiland.*

While the pieces of iron brought home in the beginning of this century by Ross and Sabine have been often mentioned, it has been less generally known that Giesecké also about the same time found a piece of iron much farther to the south, in Greenland proper. As he does not mention it in his Diary, we only have a slight evidence of this fact in the Catalogue of his collection; where this specimen, which is now in the Copenhagen museum, is said to have been found in a bog on Arveprindsens Eiland. The specimen has a peculiar appearance, showing on its surface impressions such as might be made with fingers in a soft mass. The weight is 410 grs. From this piece two small pieces were sawn off, one for the chemical analysis, and another for polishing and etching. The latter did not give the usual Widmanstätten figures, but only indistinct, shining, silver-white figures in the greyish-white ground-mass.

* Means, Heir Apparent Island.

The iron was very tough and hard. An exterior crust of malleable on was distinguished from the interior part, which latter the hammer ily crushed without beating it flat. On account of the failure of one alysis, the carbon was determined from the interior, while the other ements were determined on small hammered plates.

The chief analysis was made on 2·850 grs.

Results :

Cu	0·06
Fe	95·67
Co	trace?
S	0·09
C	1·94
SiO_2	1·40
Insol.	1·09
	100·25

I obtained a very small precipitate in the filtrate from the iron when phuretted hydrogen had been added and the solution had been neutra-d. As the quantity was too small to be weighed, it was only examined fore the blow-pipe with salt of phosphorus. The bead was blue as well in interior as in the exterior part of the flame, and thus cobalt ought to be sent. Whence has this come? It has been proved that extraordinary all quantities of cobalt and nickel may be present in many sorts of iron d for practical purposes,* and a European origin might therefore be sus-cted in the case of this iron. But the considerations set forth above in ntioning the Asuk iron, show that a Greenland and basaltic origin is also ssible.

If a piece of rock had been adhering to the iron the question would sily have been solved, but I have not been able to find any.

B. Niakornak.

Of all loose blocks consisting of so-called "meteoric iron," a block from s place which is now in the Copenhagen museum is the best known, as it s been examined both by Forchhammer† and by Lawrence Smith.‡ e Copenhagen museum received it from Dr. Rink, who on his travels North Greenland, 1848-50, got it from a Greenlander in an Esquimaux

* Weiske. Ueber den Kobalt u. Nickelgehalt des Eisens. (Journ. f. praktische emie. 1866, p. 479.

† Oversigt over det kgl. danske Videnskabernes Selskabs Forhandlinger, 1854, p. 1.

‡ l. c. p. 489.

hut between Jakobshavn and Ritenbenk. This man had found it near the shore on a plain covered with pebbles, through which the Anontok river discharges itself into the sea. Climatic difficulties, viz. snow in winter and floods in summer, prevented Dr. Rink from more closely exploring this plain.

Dr. Rink found the specific gravity of the whole piece=7·00, and that of some small fragments=7·02. Forchhammer found also for some small fragments, Sp. gr.=7·073 at 15° C. Lawrence Smith found for the pulverised iron 7·60, and an experiment made on a fragment weighing 2·7875 grs. afforded me 7·29.

The iron is very hard, shows granular fracture and sometimes small cleavage faces. When etched it shows small irregular Widmanstätten figures. Original weight 10½ kilogram. The analyses of Forchhammer (II.) and Lawrence Smith (III.) are given for use of comparison with mine (I.).

	I.	II.	III.
Cu	0·16	0·45	0·18
Fe	92·46	93·39	92·45
Ni	1·92	1·56	2·88
Co	0·93	0.25	0·43
P*	0·07	0·18	0·24
S	0·59	0 67	1·25
C	3·11	1·69	1·74
SiO_2	0·24	0·38	1·31
Insol.	1·09	—	—
	100·57	98·57	100·48

It will be seen that the analyses do not fully agree with each other, the reason of which is, I presume, that the iron is not quite homogeneous in all its parts. The same thing may be said for the residue ; it is also shown by the varying specific gravity. The determination of carbon is a mean of two, giving 3·02 and 3·20 per cent. respectively. The result of two other experiments, when the carbon was burnt in oxygen, was a little lower, viz, 2·64 and 2·83 per cent. Among the specimens from Blaafjeld similar hard varieties rich in carbon are found, and as it cannot be doubted that the iron has been once imbedded in basalt, it is very possible that it may have been taken by the Greenlanders from Blaafjeld and have been brought by them to this spot. We notice here also on fresh fractures the usual exudations of chloride of iron.

* I am indebted to the kindness of Mr. O. Christensen for the determination of phosphorus in my analysis of this specimen.

Forchhammer mentions "that in one place traces were seen of an earthy neral, but it could not be determined whether it originated from the ap-pebbles of the plain and had been cemented to the iron by rust, or ether it ought to be considered as the remains of a stony mass which had ce surrounded the iron." Perhaps there was not enough for an analysis, d microscopical investigation was not at that time sufficiently advanced decide such a question. Even now I found a trace of a crystalline ass, but on an attempt to grind it, the whole was crushed to dust. obably it was a bit of basalt.

C. Fortune Bay.

In 1852 a block weighing 11844 grs. was found at Fortune Bay on Disco the physician Rudolph, and sent to the Copenhagen Museum. Forch-mmer has only given two small communications about it, without giving analysis. He promised a further communication, but must have been dered from fulfilling this promise, as no such account has ever appeared. Originally it was very difficult to sever a piece from the whole block, but smaller pieces themselves are now easily crushed under the hammer; crushing them we get partly a coarser powder, consisting of small an-lar fragments of a colour like that of pyrrhotine, and partly of a finer and re brittle powder. Still the iron has nothing to do with pyrrhotine; ontains only a very insignificant amount of sulphur, and gives, when solved in hydrochloric acid, only a very slight odour of sulphuretted drogen. Polishing and etching afford some indistinct figures.

The chief analysis was made on 2·4005 grs. Phosphorus not traced in 6½ s. Specific gravity determined on a fragment weighing 5·6054 grs. and nd to be 7·19 at 16½° C. The determination of carbon is a mean of two ing 2·38 and 2·41 per cent. respectively. On fresh fractures the usual dation of iron chloride was remarked.

Results of the analysis:

Cu	0·20
Fe	92·68
Ni	2·54
Co	0.58
S	0·01
C	2·40
SiO_2	0·31
Insol.	0·08
	98·80

The analyses show a perfect conformity between the Niakornak and the Fortune Bay iron. As to the latter, the locality itself on the Disco coast, not far from Blaafjeld, makes it highly probable that the iron originated from this locality.

No fragments of adhering basalt could be detected.

D. Fiskernæs.

While the Niakornak, Fortune Bay and Jakobshavn* iron, perhaps also Giesecké's iron from Arveprindsens Eiland, are very naturally grouped around the basalt formation of North Greenland, this occurrence at first sight seems somewhat more inexplicable, the locality being more than 700 miles distant from the basalt. Our museum received it in 1853 from Dr. Rink, who had obtained it from Mr. Matzfeldt. It has been mentioned, but not closely examined by Forchhammer; and yet this iron, which is very similar to that found at Ekaluit, is undoubtedly the most interesting of all the loose blocks. Forchhammer himself makes the remark, that several circumstances make its meteoric origin very uncertain. The iron in question now consists of two small fragments, weighing 153 grs. Really it is a dolerite, through which the metallic iron ramifies in such a manner, that if we grind a plate of it we see the dolerite and the iron alternating with each other. I therefore give an analysis of both below.

The iron is very malleable, whereby it is distinguished from the other loose blocks, except the outer parts of Giesecké's iron. The specific gravity of some small hammered plates, weighing together 0·960 gr., was 7·06. In the chief analysis, which was undertaken upon 1·962 grs., the iron was dissolved in *aqua regia*, and phosphorus could not be detected in this solution. I did not search for sulphur, in order that I might not use too much of the iron. Results of the analysis:

Cu	0·36
Fe	92·23
Ni	2·73
Co	0·84
C	0·20
SiO_2	0·64
Al_2O_3	0·64
Insol.	1·99
	99·63

* On Nordenskjöld's Greenland expedition 1870, Dr. Oberg received this specimen from Dr. Pfaff in Jakobshavn. (Svenska Vetenskaps Akademiens Förhandlingar, 1870, p. 1069.)

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The Dolerite.—Mr. Steenstrup has kindly communicated to me the fol-ving results of a microscopical examination: "In a section of eighteen uare millimetres of the rock accompanying the Fiskernæs iron, I saw a e grained ground-mass nearly without 'basis,' consisting of small stals of a triclinic felspar, surrounded by rounded grains of pyroxene, vine, and ramified particles of magnetite and titanic iron. The mean e of these small crystals is up to 0·3 mm. Seven larger crystals of a tri-ic felspar up to 1·5 mm. in length, are disseminated in the ground-ss, the small crystals of which have been arranged around the larger s. The whole section as well as the single small crystals appear very h, and the rock is not to be distinguished from a common coarse-ined basalt from North Greenland, whence it probably originates."

The analysis agrees with the microscopical examination. This was made y by decomposition with carbonate of soda, so that the alkalies e not determined:—

SiO_2	...	...	...	50·64
Al_2O_3	...	...	...	15·98
FeO	...	...	...	14·92
CaO	...	...	...	9·39
MgO	...	...	...	5·14

t will be seen that the composition is also that of a common basalt, after all there can be no doubt as to the original locality of the iron. s easy to understand why it should be carried so far off when we re-nber that it is malleable. Now that Steenstrup has found iron in a ve in Greenland, we know how much the Greenlanders value this al, and can understand how such a piece might be carried so far by the d of man.

E. Ekaluit.

has long been known by the discoveries of Ross and Sabine that Greenlanders possessed tools, especially knives, of hammered iron, but only by the recent investigations of Steenstrup that it has been rtained where the natives have obtained this iron, for in a Greenland e at Ekaluit in the Umanakfjord, he found nine pieces of basalt, rein were contained grains of metallic iron. Really no difference could etected between the manner in which the iron is imbedded in the lt and the way in which the iron is found *in situ* in other places.

he analysis was made on 1·562 grs. On account of the small quantity aterial, phosphorus, sulphur, and carbon, were not searched for. A l amount of the latter element must be present, as I remarked a faint

evolution of carburetted hydrogen, when dissolving the iron in hydrochloric acid.

Results of the analysis :

Cu	0·23
Fe	94·11
Ni	2·85
Co	1·07
Insol.	0·61
	98·87

The iron is malleable, and the grains may easily be hammered out to small plates about half an inch in diameter. Prof. Japetus Steenstrup some years ago described some Greenland knives,* the edge of which consisted of a row of such small iron plates. They were placed in a groove in a piece of bone, the one end of the latter being used as a handle. Prof. Johnstrup found in one of the small plates as much as three per cent. of nickel. We now plainly perceive the succession ; first the iron *in situ ;* then in smaller detached pieces of basalt, which the Greenlanders put in the graves with the dead,—a distinct proof of the value attributed by them to these small pieces of iron ;—and finally, we see the tool itself with the wrought-iron : and the way of working it was simply by hammering it flat.

F. Greenland Knives.

The knives here examined are of another type than those above mentioned, and far more similar to knives of European workmanship. A largish piece of iron is hammered out to a common knife blade, and fitted into a bone handle. Evidently the Greenlanders must have had larger grains in this case than in the case of the knife of the first type ; and as it presented a great deal of interest to know whether Greenland malleable iron of such a size might really be procured, I gladly complied with a request of Prof. Japetus Steenstrup, to make these knives also the object of a chemical examination, the more so as I obtained thereby a very interesting addition to my materials.

The first knife had been found on "Hundeeiland" (Dog Island), between Disco and Egedesminde ; the other one at Sermermiut, close to Jakobshavn. Only copper, nickel and cobalt were determined.

* Japetus Steenstrup, Sur l'emploi du fer météorique par les Esquimaux de Greenland. (Compte-rendu du congrès international d'anthropol. et d'archiol. préhist. Bruxelles, 1872.)

esults :

		I.	II.
Cu	... ...	0.18	Trace.
Ni	... ...	0·23	7·76
Co	... ...		0·56

th knives were a little more than two inches in length, and consisted ver-white iron, upon which an etching had been made before I re- them, and had produced fine, winding, elevated lines. The second (II.) was in some places covered by a wax-like, greenish mass, the r of which undoubtedly was due to oxidised nickel. For the analysis grs. were used in I., in II. 2·949 grs. The whole knife I. weighed rs., and the whole knife II. 6·1 grs. In I. was found a distinct of cobalt together with a predominant amount of nickel.

was the more interesting to examine these two pieces of iron, as I by had the limits for the percentages of nickel extended. In I. we the whole percentage of nickel and cobalt 0·23—less than in the rom Asuk, where it reached 0·40 per cent. This is thus the smallest t found, if Giesecké's iron is excepted. In II. the joint amount of and cobalt was 8·32, a figure that surpasses by one per cent. the st percentage hitherto found, viz. 6·50 per cent. Ni and 0·79 per Co, the amount found by L. Smith in a piece of iron from Blaafjeld. st examined the knife I., and the small percentage of nickel found naturally raised the question whether this iron might really ori- from the basalt, although the amount of nickel found in artificially ed iron is exceedingly insignificant, even as compared herewith.* very fortunate that in the knife II. such a large amount of nickel und, as the question of the origin of the iron of this knife is thereby itably decided.

Summary of Analyses of the Greenland Telluric Iron.

	Blaafjeld (Ovifak), Disco.				Mellemfjord, Disco.		Asuk, Disco.
.....	0·16	0·16	0·19	0·23	0·33	0·48	0·14
....	91·71	91·17	82·02	59·77	93·89	92·41	95·15
.....	1·74	1·82	1·39	1·60	2·55	0·45	0·34
.....	0·53	0·51	0 76	0·39	0·54	0·18	0·06
.....	0·10	0·78	0·08	?	0·20	trace	?
.....	1·37	1·70	1·27	1·20	0·28	0·87	0·96
.....	0·31	0·46	0·59	0·39	0·46	0·90	0·68
....	1·21	2·12	1·08	3·79	—	0·60	0·51
....	2·39	0·77	8·03	22·23	1·48	4·57	1·90

* Weiske, l. c.

	Arvepr. Eiland.	Niakornak,* Jakobsh. D.	Fortune Bay, Disco.	Fiskernæs Godthaab, D.	Ekaluit, Nugssuak.	Greenland Knives.	
Cu	0·06	0·16	0·20	0·36	0·23	0·18	trace
Fe	95·67	92·46	92·68	92·23	94·11	?	?
Ni	—	1·92	2·54	2·73	2·85	0·23	7·76
Co	trace?	0·93	0·58	0·84	1·07		0·56
S	0·09	0·59	0·01	—	?	?	?
C	1·94	3·11	2·40	0·20	?	?	?
SiO_2 ..	1·40	0·24	0·31	0·64	—	?	?
Al_2O_3..	—	—	—	0·64	—	?	?
Insol.	1·09	1·09	0·08	1·99	0·61	?	?

* Contains also 0·07 per cent. of phosphorus. D means district.

It is remarkable that the amount of copper in the second analysis was very small, scarcely to be perceived, but still more astonishing is it that the percentage of cobalt does not increase in the same proportion as the nickel. Somewhat similar is the case in the analysis of L. Smith mentioned above.

III. GRAPHITIC FELSPAR.

When some years ago Dr. Nauckhoff made his careful analyses of the iron and rocks from Blaafjeld, he unfortunately chose a series of specimens which were *so faintly distinguished from each other*, that it is nearly impossible to get a clear view of the subject from them. If we compare the analyses, we find between several of them, for instance between Nos. 7, 8, 9, and 10, some resemblance as well in the mass-analysis as in the mineralogical composition. A low percentage of silica, and a high one of alumina, is characteristic in these four specimens; as also the presence of a red mineral, which Nauckhoff believes is spinel and partially also graphite. Nauckhoff has not taken much notice of the graphite, but L. Smith specially examined "la dolérite graphitique," as he calls it.* One point at that time was whether the rock at Blaafjeld did or did not contain anorthite, which was denied both by Steenstrup and L. Smith. Dr. Törnebohm, however, who made his examination nearly at the same time as L. Smith, subjected the specimens formerly analysed by Nauckhoff to a microscopic examination, and singled out from the rest, under the name of "anorthitfels," some parts of the rock which appear to belong to the very same variety that L. Smith examined chemically as well as optically without finding any anorthite. It is the merit of Dr. Törnebohm to have first called our attention to this point, but, as the results of these investigations are so different, I thought that the examination ought to be taken up again.

* l. c pp. 481, &c.

Another motive for doing this was that this peculiar rock, which is imdded as smaller inclusions in the basalt and dolerite proper, is by no eans found at Blaafjeld alone, but accompanies the iron in other places, must necessarily be inferred that there is some connection between em. In this rock are also found some reddish grains—the red mineral entioned above—which have also given rise to different interpretations; ile Nauckhoff correctly regards them as spinel, Smith, after examining m chemically and optically, believes them to be corundum. In the ecimens examined by me, the felspar always exhibited excellently reflectg cleavage-faces, even when very much graphite was disseminated in it. e latter may be intermingled in smaller or larger quantities; sometimes forms so large a proportion of the rock, that the same is more like impure graphite than a graphitic felspar. I have made a closer amination of specimens of this rock from Blaafjeld as well as from Nuk the Waigat. The reasons that I have examined the felspar from Nuk l not that taken from the other localities whence the iron also was mined will be explained below.

Steenstrup and L. Smith, who have denied the presence of anorthite at aafjeld, have described the felspar as labradorite. Both of them have ated sections of the rock with hydrochloric acid without any effect; Smith has further treated the pulverised rock with hydrochloric acid, hout being able to detect lime in the solution; which undoubtedly uld have been the case if he had had to do with anorthite. The exnation may be that these experiments have been made on the basalt per, not on the graphitic felspar (anorthitfels), the question n being whether the rock around the iron blocks was eucrite or basalt. therefore tried to treat a little more than three grains of the graphitic par with cold hydrochloric acid of twenty-four per cent. for forty-nt hours, the solution being occasionally stirred up. Hereby 4·2 per t. of lime and a little magnesia were dissolved, besides iron oxides and mina. I therefore agree with Dr. Törnebohm that this triclinic par, which is so easily decomposed by hydr hloric acid, is really rthite. Mr. Steenstrup has ground a section of the same specimen t was used for the analysis. This section was put in hydrochloric l in a test-tube, one end of which had been drawn out flat in such anner that the glass might be laid under the microscope, and the pross of the decomposition of the felspar be observed. The section was ken by degrees into smaller pieces, but it might be observed in every ce how veins of an isotropic matter were formed, and how these veins e gradually widened, the unaffected parts getting smaller. That this

isotropic matter should only be amorphous silica seemed rather doubtful, as the section must, if this be the case, have been broken at each of the veins.

I am now coming to the red grains, the spinels of Nauckhoff and Törnebohm, the corundum of L. Smith; although the latter investigator, on account of "chemical criterions," also deems the presence of spinel to be possible. Really the chemical as well as the optical criterions speak in favour of spinel being present, and it seems strange that it has escaped the attention of the renowned American chemist, that under the microscope the reddish grains appear dark in all positions between crossed Nicols. This seemed to make it certain that the mineral was crystallising in the tesseral system, not hexagonally. I ought yet to add, that Prof. L. Smith himself remarks that the mineral probably is corundum, "quoique les observations optiques ne soient pas certains."

For isolating the spinel he used two different methods. On the first occasion the graphite was burnt in a current of oxygen, and the heated residue was fused with alkaline carbonates to which a little caustic soda was added. The fused mass was treated with water and hydrochloric acid; on the undissolved residue the fusing and treating with acid was repeated. A small portion still remained, which was only decomposed by bisulphate of potash. It had the following composition:

SiO_2	0·95
Al_2O_3	92·02
Fe_2O_3	3·25
MgO	2·68
	98·90

The second time, the rock was first treated with hydrofluoric acid, then the graphite was burnt in oxygen—a very long process—then the residue was fused with carbonate of soda, and in the residue after all these operations 98 per cent. of alumina were found. Already the difference in the percentage of alumina is striking. I think that the amount of magnesia found in the first analysis are the chemical indications, from which L. Smith has drawn his conclusion as to the presence of spinel.

It at once appeared rather doubtful to me whether the spinel, if we really had to do with spinel, might pass uninjured through these violent processes, and therefore I tried to isolate it in another manner, in doing which I succeeded very well.

If the rock in a coarsely pulverised state is put gradually in small quantities into a mixture of saltpetre and carbonate of soda, the latter being kept fused at a very high temperature, the graphite will be oxidised and

the silicates will be decomposed in a very short time. After cooling the mass is thoroughly well elutriated. After elutriation with hot water, the residue was treated several times with concentrated hydrochloric acid, and after that the spinel was found quite isolated. 12 grs. of the rock afforded when treated in this way 1 gr. spinel in the form of hard dark grains, which when seen by transmitted light appear red. When laid in Canada balsam and viewed under the microscope, they also here appear red and quite fresh, and there is on the whole no difference whatever to be found between these and other grains still imbedded in the rock. The hardness surpasses that of quartz and the specific gravity is 3·45.

For the analysis the mineral was pulverised in a steel mortar. The metallic iron, which by this process had been mixed up with the mineral, was dissolved by hydrochloric acid. 0·2995 gr. then afforded the following composition :—

SiO_2	0·20
Al_2O_3 (Fe_2O_3)	80·60
Cr_2O_3	1·24
MgO	19·11
	101·15

Unfortunately I lost part of the solution in which the iron was to be determined volumetrically, but that some amount was present might safely be assumed. In the analysis the iron is given in the form of sesquioxide together with alumina, but part of it must be protoxide, which would explain the excess. In a previous analysis, made on 0·4805 gr., I found 19·57 per cent. magnesia. If then 19 per cent. MgO be added to some amount of iron oxides, we have between 20 and 30 per cent. of strong bases combined with 70 per cent. alumina, and 1 per cent. chromium oxide, wherefore I do not hesitate to pronounce the mineral to be a real *chrome-coloured spinel.*

I have further analysed *the rock itself*, the graphite being burnt in a current of oxygen and determined as carbonic acid. Results :

Graphite	6·78
Residue	93·22
	100·00

The residue was really smaller, and the loss by heat considerably larger, viz. 10·28 per cent., thus something must have been lost besides the carbon. The residue was decomposed by carbonate of soda, and showed the following composition :

SiO_2	39.75
Al_2O_3	26·08
Cr_2O_3	1·23
Fe_2O_3	12·33
CaO	12·01
MgO	4·51

I did not succeed here in isolating the spinel, which must have been more easily decomposable, in consequence of its having been kept for 20 hours heated in oxygen, a proceeding which was necessary to have the graphite burnt. The amount of magnesia and chromium-oxide may be derived partially from the spinel. Considering that neither the graphite nor any of the other constituents of this rock perhaps ever occur in the same relative proportion (L. Smith for instance found 17·50 per cent. graphite), it is not to be expected that analyses of different, nay even of the same specimens, will give the same results. It may then be of some interest to compare the analyses which have been made wholly or partially on this rock, and therefore I communicate below an abstract of the analyses of Nauckhoff, nos. 7 (I.), 10 (II.), 9 (III.), 8 (IV.) placed together with that of L. Smith and my own. Only it ought to be remembered that the graphite in the two latter analyses had been removed beforehand.

	Nauckhoff.				Smith.	Lorenzen.
	I.	II.	III.	IV.		
SiO_2	34·72	37·92	44·94	36·59	34·16	39·75
Al_2O_3	31·83	32·36	22·20	19·18	33·85	26·08
Cr_2O_3	—	0·08	—	—	—	1·23
Fe_2O_3	4·88	—	—	—	—	12·33
FeO	5·53	4·02	9·45	14·85	17·00	—
CaO	10·19	11·57	11·01	8·73	8·80	12·01
MgO	9·35	2·86	4·98	7·24	4·23	4·51
C	0·58	6·90	3·35	2·55		

Between the results, inconsistent as they are in other respects, there are yet some accordances. as in the low amount of silica and the high percentage of alumina and partially also of lime.

With a view to ascertaining whether the results here found agreed with what might be observed at the other iron localities, I also examined the felspar from Nuk in the Waigat. Mr. Steenstrup had observed that in some places the red spinels occurred along with a wine-yellow mineral, most abundant at Nuk, although it seemed doubtful whether even from this locality sufficient material for an analysis might be obtained. This was an inducement to examine this felspar, although I had not analysed

e iron from this place. For isolating the minerals, I used the method scribed above. 30 gr. were employed, but the two minerals occurg only in very small quantities the difficulties of the operation were ry much augmented, and I obtained so small an amount, that it did not ffice for an analysis. When put in Canada balsam and tried in larised light, the yellow grains proved to be anisotropic, and therefore uld not be spinel. They appeared fully fresh, but whether they be quartz another mineral I am not able to decide.

In order to ascertain whether the felspar in this rock, which did not ntain as much graphite as the Blaafjeld specimens, was also anorthite, I ated 3·044 grs. with cold hydrochloric acid of 24 per cent. during hours. A large amount of iron oxides, a little magnesia, and 0·043 gr. 11·41 per cent. lime were dissolved. Though not so much lime by far dissolved here as in the Blaafjeld specimens, yet I think it is sufficient warrant the belief that this felspar is also anorthite, considering the eness existing throughout between the felspar in question and that of aafjeld.

It has been necessary to enter into these details respecting the composim of this graphitic felspar, on account of the close connection existing tween this peculiar and interesting rock and the iron. It seems certain t it is not possible to account for the origin of the iron without also taining whence the rock therewith connected has come. I do not think t. after the recent discoveries of Mr. Steenstrup, the meteoric origin the iron will be seriously asserted. Thus two alternatives are left, . that the iron may have either been carried up with the basalt, when a fluid state it broke forth from the interior of the earth, or, that it may ve been originated, during or after the eruption, through a reduction of the ruginous minerals contained in the basalt, especially the magnetite and rine. If we accept the theory put forth by Dr. Törnebohm, which ans a very plausible one, that the graphitic felspar has originated m a marl or slate rich in lime, alumina, and carbon, andif we remember t the Greenland basalt has in many places broken forth through coals, the conjecture is probable that pieces of such beds of coal and e were broken off, and as far as the inorganic constituents were conned, were remelted, whereby oxides of iron were reduced to metal. account of some very interesting microscopical examinations, Dr. rnebohm holds it rather probable that the iron may have been reduced r the congealing of the basalt by means of bituminous matter accumud in vesicles or cavities. To me it seems more natural to assume that iron has been produced by the dry way, in a manner similar to that

by which we make iron technically. Perhaps we may expect important contributions towards a solution of the problem from a closer microscopical examination of the way in which the iron occurs in the other localities.

As I had thought it possible that the basalt of Blaafjeld, where such large blocks of iron had been formed, might contain somewhat less of combined iron, I made a series of experiments with the view to ascertain whether this might be the case. I took fragments of basalt adhering to the blocks themselves, examined them by the lens to see if they were partly of pyrrhotite and iron; decomposed them with hydrofluoric acid, reduced with zinc and determined the iron volumetrically. Although these experiments do not supply any evidence bearing upon the above view, yet I think it right to give an account of them. It appears that all the specimens tested contained the same quantity of iron as is usually found in basalt. Although there is a little difference in a few of them, it is too slight to decide anything. The whole quantity is given as protoxide. The results were:

I.	...	...	...	12·95 per cent. FeO.
II.	...	...	...	12·34 ,,
III.	...	...	...	13·63 ,,
IV.	...	...	...	14·65 ,,
V.	...	...	...	14·86 ,,
VI.	...	...	...	11·23 ,,
VII.	...	...	...	14·90 ,,

I. is compact basalt. The specimen had been surrounded with iron on all sides.

II., III., IV. and V. are all taken from basalt adhering to different pieces of iron.

VI. was taken from a large piece of fine-grained dolerite, which had been in immediate contact with the iron.

VII. finally was taken *in situ* on the shore 50 feet west of the iron.

It may be added that, although it would have been a strong evidence in favour of the reduction theory if it had been proved that the amount of iron oxide had diminished in the basalt around the metallic iron, yet of course, the above experiments by no means prove that the theory is wrong, but only that we do not get further on this way.

If we assume with Daubrée that the metallic iron has been carried up from the interior of the earth, we meet with a difficulty in explaining whence the graphitic felspar originates, as it does not seem easy to understand that the like origin could be attributed to the latter; and the latest investigations of Mr. Steenstrup distinctly show that the iron and the felspar are so closely connected that their origin must be supposed to be attributed to the same causes.

III. *On some Specimens of Lava from Old Providence Island.*

By Prof. T. G. Bonney, D.Sc., F.R.S., F.G.S., President.

[Read December 11th, 1883.]

SOME months since I received from J. G. Grenfell, Esq., of Clifton College, a few small specimens of igneous rock which he had collected in the year 1880 on Old Providence Island. This is an island in the Caribbean Sea about 90 miles off the Mosquito Coast, in lat. 13°26′ N, long. 81°18 W. It is oval in shape, 4½ miles long from N to S, and 2¼ miles wide. Barely separated from it on the North is a little island named Sta. Catalina. Mr. Grenfell describes the main island as mountainous, with three chief peaks, the highest of which rises to 1,190 ft. Spurs from these terminate on the shore in peaked hills from 300 to 700 feet high. The materials of both islands, as far as seen, were volcanic—lavas, tuffs and agglomerates; but the fragmental materials on Split Hill exhibited a more uniform stratification than we should have expected in débris simply ejected from a volcano. The rocks numbered (*d*) and (*e*) come from a cave near Morgan's Head on the west coast of Sta. Catalina, the others represent the ordinary igneous rock of Old Providence. The specimens consist of bits of dull reddish scoria, of a rather decomposed pale purplish-red or reddish-lavender porphyritic rock and a nearly black minutely porphyritic rock. All appeared to belong to a group of rather basic lavas; and on the first glance at the last named I was at once struck with its resemblance to those compact black lavas variously named augite-andesites, basaltchstone porphyrites, &c., which have recently attracted so much attention as containing a rhombic pyroxene, possibly hypersthene. I selected five of the more promising varieties for microscopic examination, and append the following description :—

(*a*). A brown-black rock, almost as dark as many basalts, fracture rather irregular with a slight rather resinous lustre, structure compact, numerous brownish-grey crystals of felspar from about $\frac{1}{20}''$ to $\frac{1}{10}''$ long, rather square in outline, also very small crystals of a black pyroxenic mineral, water surface not decomposed and slightly pitted. Under the microscope the rock exhibits a brown glassy base of minutely granulated aspect; this is due to its being rather thickly studded with very minute crystallites and granules of felspar, pyroxene and opacite. In this are scattered, fairly

thickly, larger grains of opacite and crystals of felspar and a pyroxenic mineral. The felspar is rather variable in form, but the crystals are generally approximately oblong in outline, the breadth being not seldom about half the length. Most if not all are obviously plagioclase; some show zonal banding, many polysynthetic twinning, though a 'Carlsbad' habit is not unfrequent. The extinction angle between successive lamellæ commonly varies from 20° to 30°, and sometimes exceeds the latter amount, and the least angle made with a vibration plane of one of the Nicols by the edge of a crystal is about 10°. I have little doubt that these crystals are either anorthite or labradorite, possibly both. Some of the crystals are almost clear, but the majority contain inclusions. Many of these are brown glass, which is sometimes quite clean, but at others contains opacite and other crystallites; for these enclosures I cannot make out any rule, they are not restricted to the larger crystals. Granules of a pyroxenic mineral are often included. Here and there a crystal appears to become fused into the adjacent base by being crowded with crystallites. In short these felspars exhibit the usual features of crystals which occur in rocks of this nature. There may also be some cavities, but I do not detect any bubbles. The pyroxenic constituent is fairly abundant. It has a rather fibrous look, is slightly dichroic; the prisms extinguish as nearly as possible parallel to their edges. In cross section the pinacoidal planes are best developed, the prismatic cleavages are the more prominent and constant, and the plane of the optic axes appears to be parallel with a pinacoidal face. The green tint is most marked in a longitudinal section when its axis is parallel with the vibration plane of the polariser (alone), the red when transverse. In two parts of the slide the felspar crystals are grouped so as to enclose a portion of the base. This, however, differs from that outside in being a clear brown glass with only a few granules of opacite, and in one case two or three small crystals of the rhombic pyroxene.

(*b*). A rock generally similar to the above, but slightly browner, and a shade rougher in fracture, and less lustrous. Under the microscope the ground-mass has not quite such a glassy aspect, as the included crystallites (doubtless of felspar) are rather larger and give to the slide more of a 'felted' look. The larger crystals of felspar are similar to the above, but with fewer glass enclosures. There is some of the rhombic pyroxene, but certain other crystals appear to be normal augite, well marked octagonal prisms being fairly abundant; there are larger grains of iron peroxide.

c). Differs but little from the above, macroscopically or microscopi-
y, but is in all respects, especially as regards the matrix, a little
rer to (*a*). The description of that will apply to the larger crystals of
, word for word.

d). A compact purplish-grey moderately dark rock, clouded here
there with a dull red, with small dead-white crystals of felspar
ttered about. It weathers to a pale lavender-grey, and was selected
he most hopeful example of the more decomposed specimens. Under
microscope we see that, allowing for its condition, it has a general
mblance to the above described, being perhaps nearest to (*b*); the
er crystals are less numerous, but a decomposed plagioclastic felspar
a grain or two of a black bordered brown pyroxenic mineral can be
gnised. Several dark brown globulitic spots and grains of iron
de are scattered about.

). A purplish-red rock, with sundry small vesicles on the outer surface
ng a decidedly scoriaceous aspect. Minute crystals of a decomposed
ar and a darker mineral are visible. Under the microscope it
nts a general resemblance to the above described, but is rather de-
posed, and the base is more variable in colour, having a dingy
dled look. The felspar is much decomposed, and has often broken
in the grinding of the slide; the pyroxenic constituent is generally
ered with opacite and darkened, and is thus difficult to determine.

ma indebted to my friend J. J. H. Teall, Esq., M.A., F.G.S. for the
wing notes on the chemical composition of one of these dark lavas,
from which the slide was prepared from Old Providence Island.

"1·0530 gramme of the substance dried at 110°C and fused with the
d carbonates of soda and potash gave ·6436 gr. of silica, ·1868 gr. of
lina, ·0628 gr. of ferric oxide, ·0574 gr. of lime, and ·0706 gr. of
nesium pyro-phosphate.

. "1·0846 gramme heated in a sealed tube with hydrofluoric and sul-
ic acids required 4·75c.c. of permanganate of potash solution (1 c.c.
0551 gr. of Fe.) to convert the ferrous into ferric oxide.

. "1·1006 gramme, dried at 110 and treated according to Lawrence
h's method, gave ·0994 gr. of the chlorides of sodium and potassium,
1192 gr. of the double chloride of platinum and potassium.

. "1·0578 gr. dried at 110° and heated to redness in a current of air
d ·0269 gr. of water.

Whence it follows that the rock contains :—

SiO_2	61·12	per cent.
Al_2O_3	17·73	,,
Fe_2O_3	2·52	,,
FeO	3·10	,,
CaO	5·45	,,
MgO	2·39	,,
Na_2O	3·01	,,
K_2O	2·09	,,
H_2O	2·54	,,
	99·95	

Specific gravity of specimen analysed 2·582.

" The loss on ignition was 2·31 per cent., a result which is seen to ag very well with the direct determination of water when we remember t the ferrous iron would take up oxygen during ignition.

" The evaporations were all performed in platinum vessels, so that excess in the analysis, due to the corrosion of glass vessels, is to be expecte

I am also indebted to the same gentleman for the annexed series analyses for comparison with the above; from which it will be seen not o that they form a well marked group of closely allied rocks, but also that difference of the last of these (No. VI.) from the rest and from this Providence rock is extremely small. Yet that is a porphyrite from Cheviots of Old Red Sandstone age, while all the others are later Terti or recent. When to this we add the microscopic resemblance no below, it becomes difficult to maintain the distinction so often, and in opinion so wrongly asserted to exist between Pre-Tertiary and subsequ igneous rocks.

	I.	II.	III.	IV.
SiO_2	61·37	60·71	61·64	62·76
Al_2O_3	15·76	16·00	17·44	18·10
Fe_2O_3	4·06	2·09	0·82	5·14
FeO	2·94	3·87	3·99	—
MgO	2·86	3·07	3·05	2·59
CaO	7·27	5·17	5·86	6·03
Na_2O	3·04	2·74	3·45	3.45
K_2O	0·71	3·78	1·15	1·35
H_2O	2·64	1·48	2·64	—
	100·65	99·92	100·04	99·42

			V.	VI.
SiO_2	...	...	62·00	63·0
Al_2O_3	...	...	17·84	14·9
Fe_2O_3	...	...	—	4·7
FeO	..	...	4·40	—
MgO	...	...	2·64	2·8
CaO	...	...	5·37	4·8
Na_2O	...	...	4·29	4·0
K_2O	...	...	1·47	1·9
H_2O	...	...	1·66	4·0 (Loss).
			99·67*	100·1

Hypersthene Andesite—St. Egidi, Steierwartz. Niedzwiedski, Min. h. 1872, p. 255. This rock macroscopically bears the closest resem- ce to the Old Providence Lava and the Cheviot Andesite.

. "Augite Andesite"—White Rock, Cedar Mountains, Utah. King, l. Expl. of the 40th Parallel, 1877. II. 466.

I. "Augite Andesite"—Cortez Range, Wagon Canon, Nevada. King, l. 40th Parallel, 1877, II. 582.

. Andesite from the Volcano of Rincon de la Viega (Andes). Dr. O. iess. Beiträge zur Kenntniss der Trachyte. Neues Jahrbuch 1866, 2.

Pumice of a Hypersthene-andesite from Mount Shasta. A. Hague . P. Iddings, American Journal of Science, 1883, p. 230.

. Andesite with Rhombic Pyroxene, Cheviot. Teall, Geol. Mag. h 1883.

s. I., II., and III. are quoted from Roth's Beiträge zur Petrographie blutonische Gesteine.

om the above description it is evident that we have in these speci- from Old Providence Island representatives of the group of Augite sites, which contain a rhombic pyroxene, probably hypersthene. group, as is well known, has recently attracted much attention, and y refer readers for further particulars and for references on the sub- o the excellent Papers of Mr. Teall and Mr. Waller in the *Geological azine* (Dec. II. Vol. x. pp. 100, 252, 290). To the former gentle- I am indebted for the opportunity of comparing these Old Provi- specimens with several slides obtained from various localities. The blance is in some cases very striking; the Old Providence speci- (especially *a*, *b*, *c*) closely resemble in their microscopic structure an

ith $TiO_2 = 0·17$. P_2O_5 0·29 total in all 100·13. There was a trace of MnO.

'augite andesite' from Bagonya, and another from Dolny Tured, Kremnitz, also anorthite trachytes from Lorinczi, from Aphroessa (Santorin), (1866), and "Kleiner Eliasberg" Thera. They present also considerable resemblance to his slides of "Pitchstone porphyrite" from the Cheviots, especially from Carl Croft, Blindburn, Fernhaugh, Windyhaugh, Cognet, and Alvin; and to one of the same rock (though less close) from a foreign locality, Vethalm. I also note a resemblance to an anorthite-trachyte from Matra, and from Borac (S. Servia) in my own collection. There are also resemblances macroscopic and microscopic to some specimens brought me by Mr. Whymper from Antisana, Pichincha, and Chimborazo (Andes) and macroscopic to specimens in my collection from Kremnitz.

A paper has recently been published by Messrs. A. Hague and J. P. Iddings (Notes on the Volcanoes of Northern California, Oregon, and Washington Territory*), to which Mr. Teall and Prof. Judd have both called my attention, giving a very full description of the andesites of Lassens Peak, Mount Hood, Mount Shasta, and Mount Ranier, extinct volcanoes, now forming lofty peaks in the chain of the Sierra Nevada. These observers were successful in isolating a sufficient quantity of the rhombic pyroxene for chemical analysis, with the following result:—

SiO_2	50·33
Al_2O_3	0·97
FeO	22·0
CaO	1·88
MgO	23·29
MnO	0·64
	99·11

Optical examination of isolated crystals also confirmed its orthorhombic character: so there can be little doubt that the mineral is a true hypersthene. The authors also call attention to the fact that "hypersthene is the substitute for olivine in rocks, differing from basalt in a somewhat higher silica percentage, the former mineral being as it is simply the bisilicate of the same Fe Mg elements." It is however noteworthy that the most frequent associate of olivine in the peridotites is not hypersthene but some variety of the closely allied mineral enstatite, usually bronzite. (Compare with this the occurrence of diallage in gabbro, the peridotites appearing to be generally deep-seated rocks.)

* *Amer. Jour. Scien.* Vol. xxvi. p. 222.

The investigations of these gentlemen fully confirm those of Mr. W. ross and Prof. Fouqué, so that we need not hesitate to admit this rhom- ic pyroxene to be a true hypersthene, and recognise a rather extensive nd wide-spread group of rocks characterised by its presence, to which elong these lavas of Old Providence island. It will perhaps hardly be ecessary to form a distinct species for them, or mark them off more trongly from the normal augite-andesites than, in the case of basalts, we hould separate one from which olivine is absent, from one in which it is ather abundant. Examination of the peridotites shows us that the resence of enstatite (bronzite), augite, or hornblende, has hardly more han a varietal value, but we may conveniently form a sub-group, hypers- hene-augite—andesites which will be related to the normal augite- ndesites, much as olivine-basalts are to normal basalts.

IV. *Note on a New Mode of Occurrence of Garnet.*

By H. Louis, Assoc.R.S.M.

[Read December 11th, 1883.]

GARNET is most commonly found in the form of separate crystals embedded in metamorphic rocks; occasionally, but comparatively rarely, in beds or veins. On a recent visit to the Pyrenees, in the Province of Catalonia, I found this mineral forming what appears to be a true dyke. I first noticed an outcrop of it in the steep banks of a brook, in one of the higher valleys of the main mountain chain. At this point it had the appearance of a vein, almost vertical and running nearly East and West; the wall rock was a highly metamorphic schist, so that its stratigraphical relation to the garnet could not well be made out; however, the general strike of the strata in this district is about East and West. At this point the dyke was about 2′ thick; one of its walls was exposed, and appeared to have undergone a good deal of alteration, being darker in colour, more fissile and more friable than the shales at a little distance off; it had also been mineralised by the development in it of small disseminated crystals of iron pyrites. On crossing the brook, I found the same phenomena repeated at a point facing the above mentioned, and on top of the hill fronting and at a distance of some 300 yards from the first locality a third outcrop, all in the same direction, was visible; these three exposures were evidently all on the same dyke. On top of the hill the dyke was about 18″ thick, and the wall-rock consisted of chloritic schists, containing embedded garnets and iron pyrites. At a distance of over a mile from this spot, but in a direction which I could unfortunately not determine, as heavy mists were obscuring the view, I found another outcrop of the same mineral. Here the dyke was very thick, measuring some 5½ yards across, of pure massive garnet rock, free from intermixture with any other mineral, except a little calcite occasionally near the walls. One wall of the dyke consisted of a mass of highly crystalline white limestone, traversed in places by thin films of amianthus. On the other wall an old level had been driven, which was completely blocked up at the time of my visit; the object of the level seems to have been to get what is probably the mineralised wall of the dyke, the minerals obtained being iron pyrites and zinc blende principally.

The garnet from these various localities seems to be exactly similar. It is massive crystalline and very free from impurity ; whenever any cavity occurred in the mass it was always covered with well-formed crystals, exhibiting usually the faces of the rhombic dodecahedron and the icositetrahedron (∞ 0 and 202).

The mineral is rather brittle, its hardness seems low for garnet, and its specific gravity high, being 3·58 ; hence it is in all probability an iron garnet. Subjoined is a rough analysis:—

SiO_2	...	33·56	33·42
Al_2O_3	...	15·64	
Fe_2O_3	...	9·75	
MnO	...	10·39	10·36
CaO	...	26·92	26·90
		96·26	

Magnesia, alkalies, water, &c., not determined.

Formula about 2 (SiO_2, R_2, O_3) + 3 (SiO_2, 2 RO).

V. *Note on a Case of Replacement of Quartz by Fluor Spar.*

By the Rev. Prof. T. G. Bonney, D.Sc., F.R.S., President.

[Read February 12th, 1884.]

THIS unusual substitution appears to have taken place in a rock found by Mr. R. N. Worth, F.G.S., on Trowlesworthy Tor. The specimen was a loose block, and the rock to which Mr. Worth has given the name of Trowlesworthite has not yet been discovered *in situ*. The rock consists of red felspar, fluor-spar, and tourmaline, associated with quartz, and its general character and microscopic structure are described in papers published in the Transactions of the Royal Geological Society of Cornwall, Vol. X. p. 177. The reasons for believing that the rock had been formed from the normal granite of the neighbourhood by substitution of fluor spar from the quartz were the following:—

(1). The fluor-spar occupies about the same proportion of, and is similarly dispersed in the Trowlesworthite as the quartz in the normal granite.

(2). The quartz in the Trowlesworthite is in such intimate association with the black tourmaline, that it seems most probable that this, as in Luxullyanite (see *Min. Mag.* Vol. I. p. 215) is formed from the destruction of a certain part of the felspar, when a considerable amount of silica would be set free; brown tourmaline replacing the mica as in that rock.

(3). The quartz in the normal granite is very full of microlithic enclosures and cavities, while that in the Trowlesworthite is unusually free from these. Using a popular term, the one when viewed with a low-power objective looks 'dirty,' the other 'clean.' To this rule one grain only in the latter rock is an exception, and in that the needles of black tourmaline are wholly wanting.

VI. *Notes on "Enargite," from Montana, U.S.A.*

By Wm. Semmons, Past President of the Liverpool Geological Society.

[Read February 12th, 1884.]

THE deleterious effects of small quantities of Arsenic when present in Copper are well known to all who are concerned with the working of this latter metal, and the elimination thereof is consequently an object to which the copper smelter pays special care. Though a large number of minerals, some of which are of exceeding beauty, are found composed of Copper combined with Arsenic acid, the direct combinations, as Arsenide and Sulph-Arsenide, are comparatively rare.

Dealing to-night only with the latter group, we notice that Brooke and Miller in the 1852 edition mention as its sole representative "Tennantite," with its variety Kupferblende, and note its occurrence in small attached crystals rarely massive. In the appendix another representative is added, "Enargite" from Peru. Dana, in 1874, "System of Mineralogy," gives no new combinations, but adds the further localities for Enargite—New Grenada, Mexico, South Carolina and Colorado. By this time too Breithaupt, Rammelsberg and Dauber had been able to measure its crystals and describe more fully its physical characters. In the first supplement of the "System" a mineral occurring in small black brilliant crystals, also massive and containing copper, sulphur, arsenic, and 6 per cent. antimony, and found in California, is given as a variety of Enargite.

Famatinite containing 10·93 per cent. antimony and 6·48 iron, but otherwise agreeing with Enargite and being found with it, is mentioned in Appendix III. The angles of Famatinite were found by Vom Rath to be identical with those of Enargite.

Clarite from Baden having the composition of Enargite, but differing from it in colour, was named by Sandberger in 1874.

Luzonite from Luzon Island, Manilla, was described by Weisbach in 1874. It is of nearly similar composition to Enargite, but differs from it in cleavage and colour. Dana and Brush consider Clarite and Luzonite are only varieties of Enargite.

These being so far as I knew the only localities where minerals of this composition had been obtained, it was with exceeding interest that I heard of an ore being found in Montana containing 20 per cent. of arsenic. Through the kindness of my friends Messrs. Lawn and Davey I was enabled

to obtain several specimens, and have now the honour of submitting the result of my investigations to this Society.

Crystals are very rare, and are small when found. Though not clearly defined enough to enable measurements to be taken, the crystals give the planes of the rhombic prism, also those of the macro-pinacoid and brachy-pinacoid terminated by macro- and brachy-domes and the basal-pinacoid. The symmetry is therefore that of the ortho-rhombic system. The cleavage planes are remarkably distinct and coincident with those of the rhombic prism and of the basal-pinacoid. They are highly striated like those of stibinite. The mineral thus cleaves into little rhombic prisms. Fracture uneven.

The hardness may be taken as 2·5, for it leaves a black powder on calcite, while it easily scratches gypsum. It soils the fingers when handled. The specific gravity, taking the mean of several specimens, is 4·3. Mr. Grenville Cole, F.G.S., of the Normal School of Science, South Kensington, determined the S.G. of a large specimen with a little quartz in it as 3·92 (by Walker's method), which may be regarded as confirmatory of my results. Colour when fresh broken is lead-grey, but it rapidly tarnishes on exposure, and becomes darker, when it much resembles blende. Streak black.

Pyrognostic Characters.—In closed and open tubes gives ordinary reactions for sulphur and arsenic. The mineral decrepitates at first and also exfoliates before the blowpipe, giving rise to worm-like threads, vermiform. I was much interested when testing the mineral before the blowpipe to find it gave no indications of antimony being present. Its appearance and structure are so similar to Stibnite, that one almost unconsciously looked for the antimony sublimate. But notwithstanding I worked with the aluminium plate of Ross, I could not find a trace of antimony. I therefore asked Mr. Lionel Fulcher of the City of London College, and Mr. Aug. Loos of the Peckham Technical School to test for antimony specially, and the result of their kind efforts agreed with mine. Thereupon my friend Mr. Terrill of Swansea very kindly undertook to make a complete analysis, and the results of two he made are given below—

	I.	II.
Copper	45·80	45·76
Arsenic	18·64	18·66
Sulphur	31·30	31·30
Silica	2·50	2·50
Iron	·80	·80
	99·04	99·02

The silica is evidently an impurity, and the proportions of copper, arsenic and sulphur stand as

Copper	47·84	per cent.
Arsenic	19·47	,,
Sulphur	32·69	,,
	100·00	

The composition is therefore nearly the same as Enargite; but as it differs from this mineral in hardness, cleavage, and pyrognostic characters, I should be inclined to give it a distinctive name, and class it under the Enargite group of sulph-arsenides of copper with Famatinite, Clarite, Luzonite and Guayacanite. All these are essentially similar in composition with a formula $3\ Cu_2\ S + (As\ Sb)_2\ S_5$, but differ in structure and other physical characters from one another sufficiently to be called under specific names.

The mineral is found with pyrites, bornite, covelline and quartz in Montana, U.S.A.

VII. *Analysis of an altered Siderite from Helton Beacon Lead Mine, near Appleby.*

By C. O. Trechmann, Ph.D., F.G.S.

[Read February 12th, 1884.]

IT appeared of interest to determine the nature of the alteration which has changed the light greenish or brownish yellow siderite to the dark, almost perfectly black, glossy crystals so often seen on specimens from this neighbourhood.

The material, gathered from the heap of a mine, consisted of massive siderite, crystallised on its natural surfaces in the form of small curved primary rhombohedrons, and associated with quartz, pyrites, blende, and other minerals. The alteration had commenced on the more exposed external parts, and had gradually extended inwards to a depth of about one eighth of an inch, though here and there in deeper cavities the crystals remained quite fresh. The colours ranged from black, or deep blackish brown, through purplish brown and light brown to the yellowish or greenish original tint. There is no perceptible difference in the vitreous lustre of the fresh and altered parts.

For analysis only the most altered crystals were detached and carefully selected, in order to secure as nearly as possible the most advanced stage of the alteration. The rust-brown powder was dried at about 100° C. (a loss of weight of about 1 per cent. occurred, which appeared due in part to hygroscopic moisture) and was submitted to analysis with the following result:

	I.	II.	III.
CO^2 ...	33·49	—	—
SiO^2 (gangue)	1·53	1·65	—
FeO* ...	—	51·50	—
MnO ...	—	5·92	—
CaO ...	—	3·21	—
MgO ...	—	2·86	—
H^2O ...	—	—	1·48

* The iron is all given as FeO for simplicity.

From these numbers I have calculated the composition as under:

		Atomic ratio.	
SiO^2 (gangue) ...	1·59	—	—
$FeCO^3$	63·69	—	—
$MnCO^3$	9·59	—	—
$CaCO^3$	5·72	—	—
$MgCO^3$	6·01	—	—
Fe^2O^3	13·30	831	1
H^2O	1·48	822	1
	101·38		

No attempt was made to determine the state of oxidation of the manganese in presence of a ferrous salt, and in the calculation I have therefore assumed that the manganese carbonate was unaltered, and that only the ferrous carbonate had suffered a change. It is, however, probable that it has also been in part decomposed to manganic hydrate; in which case the result of the calculation will not be impaired because the atomic weights of iron and manganese are so nearly alike.

The atomic ratio of the ferric oxide and the water given off at red heat seems to suggest that the hydrate has a constitution similar to that of göthite (Fe^2O^3, H^2O), and that on further alteration more water may be taken up.

VIII. *Notes on a Picrite (Palæopicrite) and other Rocks from Gipps' Land, and a Serpentine from Tasmania.*

By Professor T. G. Bonney, D.Sc., F.R.S., F.G.S., &c., President.

[Read February 12th, 1884.]

THE rocks whose microscopic structure is described in this paper were collected by my friend, M. G. Stuart, Esq., during a tour in Australia, under the kind auspices of A. W. Howitt, Esq., F.G.S., the well-known geologist, who has so largely added to our knowledge of one of the most interesting districts of that continent.* Some of them have been already noticed by that gentleman, but as the volumes in which his descriptions are published are not very accessible to English readers, and as two of them are rocks to which I have devoted special attention, I have ventured to bring them to the notice of our Society.

Swift's Creek, Gipps' Land.—Picrite.—A moderately coarsely crystalline dark green rock, containing crystals, up to about ½ inch diameter, of a blackish mineral, with two easy cleavages meeting at angles of about 120°. Their surfaces have a bright lustre, and are interrupted by enclosures of a non-reflecting mineral. In this respect they much resemble bastite, but the peculiar 'brassy' appearance of that mineral is wanting. The rock weathers brown, and is extremely like the picrite of Schriesheim in the Odenwald. The predominant mineral in the slide is a pale green hornblende, which is clearly the mineral of the larger crystals, and occasionally occurs in aggregated smaller crystals. It is not very strongly dichroic, but gives characteristic extinction angles and cleavages. Associated irregularly with this, and seemingly having solidified rather prior to it, is a slightly brownish, almost colourless, and sometimes rather 'dirty looking' mineral, which from its cleavage and extinction angles (not very easy to observe owing to the granular habit of the mineral) appears to be an augite, with a rather diallagic habit. From its relation to the hornblende I cannot help suspecting that much of the latter is of secondary origin—a kind of uralite—as I have already observed in other picrites. Irregularly interspersed

* *Quar. Jour. Geo. Soc.* Vol. XXXV. p. 1. See also the volumes of the *Victoria Geol. Survey*.

about the slide and forming the interruptions to the larger hornblende crystals are grains of olivine, fairly well preserved, except that the cracks are outlined by a black staining. Here and there incipient serpentinisation may be noted, and from the brown colour of the result, as well as from the above staining, I should infer that the olivine was rather rich in iron. Scattered very irregularly about the slide, but often roughly grouped, are several small grains of a rather resinous looking, clear, but darkish sap-green colour. They exhibit indications of a cleavage probably octahedral, and do not depolarise light, so that I think I may venture to identify them with picotite (pleonaste). It much resembles that described in my paper on the Lherzolite of the Ariège (*Geol. Mag.* Dec. II. Vol. IV. p. 59), but is yet more distinctly green, having no tinge at all of brown.* In one or two cases the grains have almost a filmy aspect, and are enclosures in a hornblende crystal. A few grains of a black iron peroxide are scattered about, and in one part of the slide there is a little of a plagioclastic felspar. I note a flake or two of brown mica in the rock, but it happens not to occur in the slide. The rock is therefore a very typical picrite (or 'palæopicrite' of many authors), and in chemical composition probably differs little from the Schriesheim rock, except that we may expect a small amount of chromium to be present.

Diorite (*typical*), *Gipps Land*.—A moderately coarse crystalline white and dull green rock, of slightly foliated aspect. Under the microscope it is seen to consist of felspar (plagioclastic), quartz, and about equal quantities of green hornblende and brown mica. The felspar is in fair sized, generally well-defined crystals, with characteristic twinning. It is not very well preserved, and is probably either oligoclase or albite. The quartz is remarkable, it occurs in rather irregular streaks formed of aggregated granules of varied size and rather irregular outline, 'clotted' together in a way that is common in mica schists. I never saw this structure in a rock that had indubitably consolidated from a state of fusion; yet the felspars, by their form and general aspect, suggest an igneous origin. They give, however, indications of fracture, so that I am disposed to the opinion that the rock is a true diorite, but that the abnormal character of this specimen is due to local crushing, and subsequent cementation by infiltrated quartz.

Balgobach Hill. Dyke.—A dark felstone with light coloured felspar crystals of rather rounded form, and a crystal of black hornblende, the part remaining being about ¼ inch in diameter. Ground-mass crypto-

* Rosenbusch, *Mikros. Physiogr.* Vol. II. p. 538, mentions the occurrence of Picotite in Picrite.

crystalline, pretty thickly studded with crystallites of felspar, hornblende (frequently belonititic) and filmy green minerals, sometimes rather ferrite-stained. Most of these appear to be hornblende, but some may be slightly altered magnesia mica or a chlorite. In the ground-mass are (1.) Crystals of felspar, often rather rounded externally. One or two may be orthoclase: most of them are certainly plagioclase, exhibiting zonal banding or polysynthetic twinning. With some hesitation I refer these to oligoclase; their worn and rounded aspect favours the idea that they were formed considerably anterior to the last consolidation of the rock. (2.) Hornblende. Most of this occurs in crystals from about ·01 to ·02 inch diameter, sometimes showing the characteristic external form and prismatic cleavage, sometimes rather fibrous in structure. The larger crystal of hornblende mentioned above is included in the slide, and proves to be a group of four. These contain as interpositions, magnetite, apatite, biotite, and several rounded grains of plagioclase felspar. The last occur similarly to the olivine grains in the larger augite or hornblende crystals of a picrite. So far as my experience goes, these felspar interpositions are not very common. There is some apatite and several grains of iron peroxide, probably magnetite (one exhibiting a skeletal structure) in the slide. There is no appreciable amount of free quartz in the slide, so that the rock must be named a porphyrite.

From a Lava Stream, Gipps Land.—A compact dark rock, with very faint indications of a fluidal structure and some small whitish felspar crystals not exceeding $\frac{1}{8}$th inch in diameter. The slide under the microscope shows a distinct fluidal structure, and when examined with a $\frac{1}{8}$th objective exhibits a clear glassy base crowded in part with minute granules and trichites of opacite and ferrite, and with other microliths too small to be determined. In this matrix are embedded fragments of lava, presenting various slight structural or mineral differences, together with several small felspar crystals, often rather rounded in outline, which contain glass inclusions; generally the mineral is rather decomposed. The majority are orthoclase, but one or two show plagioclastic twinning. In parts of the slide small grains of clear quartz are rather frequent. The rock then is a rhyolite, probably with a considerable percentage of iron and a not very high one of silica.

Omeo, Victoria Plains, running in Dykes through the Country.—A buff-coloured felstone, consisting of a somewhat granular intimate mixture of quartz and rather decomposed felspar, with crystals of quartz (bipyramidal) and decomposed felspar (small). Under the microscope the ground-mass exhibits a cryptocrystalline structure approximating to micrographic or

pherulitic, fairly perfect spherulites appearing in parts of the slide; these, owever, have no definite boundaries, but are confusedly intergrown (see Daubrée, Geol. Exper. Vol. I. p. 170, fig. 45). A few small scales of a olourless mica are scattered about. Some of the quartzes contain a fair umber of cavities (exhibiting in one or two a linear arrangement). These re often empty and stained, but some contain fluid with rather small ubbles, others are very clear. There are enclosures of ground-mass. The lspars are rather decomposed, but plagioclase as well as orthoclase is pre-ent. There are some scales of a dirty brown mica, probably lepidomelane, ith opacite and ferrite. The rock accordingly is a typical quartz-felsite quartz-porphyry of many authors).

From the same Locality and from a parallel Dyke.—A somewhat similar ock to the last described, but rather more compact and without quartz or lspar readily visible to the eye. A little yellower in colour. The icroscopic structure presents a general similarity, but is rather more efinitely spherulitic. There are numerous small irregularly shaped grains f pretty clear quartz, often clustered, but none of conspicuous size, and o isolated felspar crystals. The same mica as in the other slide. Also quartz felsite.

Mount Pleasant. Part of the Sisters, Omeo.—A very pretty fairly com-act felstone of pinkish grey colour, containing darkish bipyramidal quartz nd light reddish felspar crystals up to about ·2″ diameter. Under ne microscope the ground-mass exhibits a minute microcrystalline tructure, and evidently is largely composed of felspar, which is decom-osed and ferrite-stained. The larger felspar crystals also are much ecomposed; so far as I can ascertain they are orthoclase. Microlithic nclosures and cavities are rather abundant in the quartzes; the latter sually containing bubbles which vary from about $\frac{1}{8}$th to $\frac{1}{4}$th of the total olume. The rock, like the last, is a quartz-felsite.

Tasmania.—Small fragments of a blackish serpentine containing very ty-ical bastite. I have given so many descriptions of the structure of serpentine hat it is only needful to say this is a good example of an altered olivine rock, f which mineral indeed a few small 'kernels' still remain in one corner of he slide; the black 'strings' are stronger in one direction than in that ransverse to it, and are very rudely parallel, from which I infer a slight endency to a banding in the original rock. Next to the strings comes a one of nearly colourless serpentine, with a clearly marked fibrous structure t right angles to the strings, and within this is a greener serpentine, of ss definite structure. There is a fair amount of enstatite, more or less nverted into a serpentinous mineral, but still retaining indications of its

cleavage structures, and generally free from iron stains; but in one place what may have been an enstatite crystal is almost wholly replaced by iron peroxide, and with it two or three grains (which apparently consolidated after the olivine and enstatite) of a closely cleaved rather dirty looking mineral, which from its extinction angle is clearly diallage. As usual, a few large grains of magnetite are scattered about. The rock then has been an enstatite-diallage-peridotite.